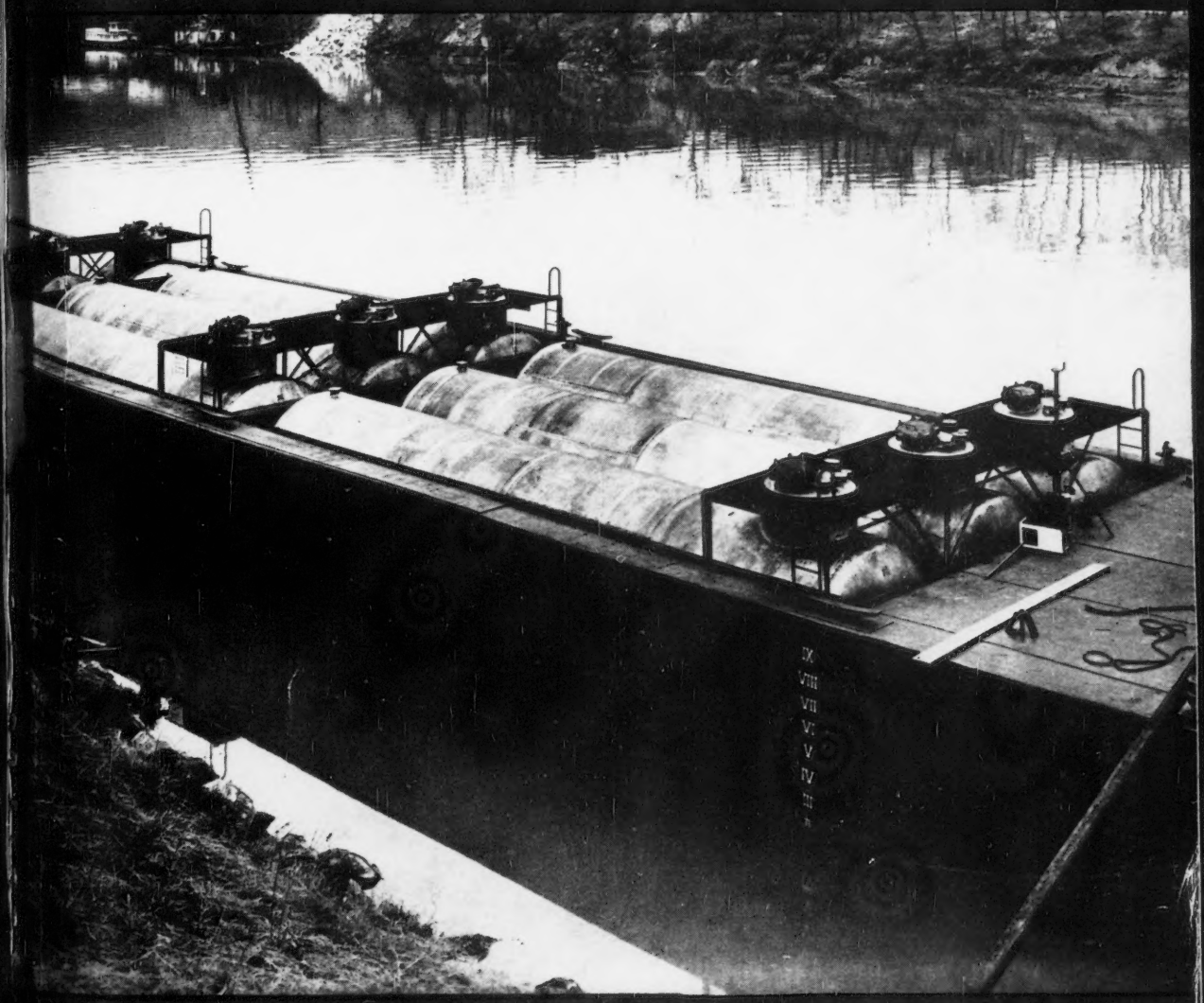
Corrosion

Official Publication
NATIONAL ASSOCIATION OF CORROSION ENGINEERS



Vol. 6 JANUARY, 1950 No. 1

PROTECT or PAY

You have no other choice!

Corrosion costs industry over $6,000,000,000 annually. No business escapes its effects. Attacks by acids, alkalis, salts, gases and atmospheric conditions cause untold damage that often is overlooked until too late.

Don't risk needless waste. Most conventional coatings fail when corrosion threatens. That's why Amercoat is designed to give *extra protection* against surface failure. Highly resistant to a wide variety of chemicals, brines, fumes, weathering and abrasion, it is available in a number of formulas, *each designed to meet specific conditions.*

Corrosion ruined this valve. Amercoat protection would have multiplied its useful life many times over. Be sure your plant and equipment are safe from corrosion damage. Protect with Amercoat.

AMERCOAT CORPORATION

A Division of

AMERICAN PIPE AND CONSTRUCTION CO.

4809 Firestone Blvd., South Gate, Calif.

Check danger points like this in your plant —

Piping • Machinery
Walls and Ceilings
Fixtures • Tanks
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...and all other areas exposed to agents of corrosion or contamination.

FOLLOW THE LINE OF most RESISTANCE

We have coated and wrapped more than 200 million feet of pipe, sizes ½" to 60" both inside and outside (and that's a lot of pipe in anybody's language). Ninety-six (96) of the top hands in the business.

By the addition of more and better equipment, we are ABLE, WILLING AND READY to handle both your new and used pipe jobs. Complete reconditioning services available.

"PUTTING *Permanence* IN PIPE"

MAYES BROS. INCORPORATED HOUSTON

DOWELL
MAGNESIUM ANODES

Help you control corrosion of underground metal

Free booklet tells you how!

Do you have all the facts on this low-cost, effective means of protecting buried metal against corrosion? Here is a new booklet filled with basic information on the use of Dowell magnesium anodes for control of corrosion on pipe lines, tank bottoms, and other types of buried metal.

This 16 page illustrated booklet will give you the fundamentals of the use, design and installation of effective magnesium anode installations. It explains how to calculate adequate current requirements, the number of anodes required, and the type anodes to use. Other points covered are how to locate the anodes for maximum effectiveness and the recommended procedure for installation.

Included in the booklet are typical case histories showing the results obtained when Dowell magnesium anodes were used to control underground corrosion. A study of these case histories will explain why so many leading businesses and municipalities are using Dowell magnesium anodes to protect their underground installations against costly losses due to corrosion.

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Tulsa 3, Oklahoma

Please send me a copy of your free booklet "Dowell Magnesium Anodes."

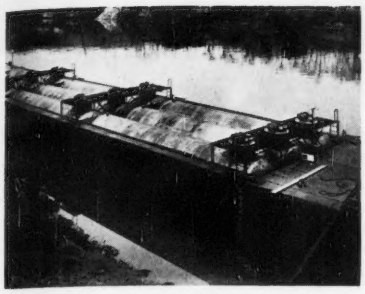
Name_____

Title_____ Firm_____

Address_____

Look to **DOWELL**

MAGNESIUM ANODES FOR CORROSION CONTROL



THIS MONTH'S COVER — Aluminum's light weight and other valuable properties solve economically the problem of transporting acetic anhydride over inland waterways. Each of the nine tanks shown is 10 feet in diameter and 46 feet long. More on this topic will be found on Page 1, News Section. (Photograph supplied by Aluminum Co. of America.)

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Entered as second class matter October 31, 1946, at the Post Office at Houston, Texas, under the act of March 3, 1879.

Corrosion is Indexed Regularly by Engineering Index.

Corrosion devoted entirely to CORROSION

Research and Control

Published monthly as its official journal, by the National Association of Corrosion Engineers, Inc., at Houston, Texas, U. S. A., to provide a permanent record of progress in the control of corrosion as described in papers prepared for the Association and from other sources.

VOL. VI JANUARY, 1950 No. 1

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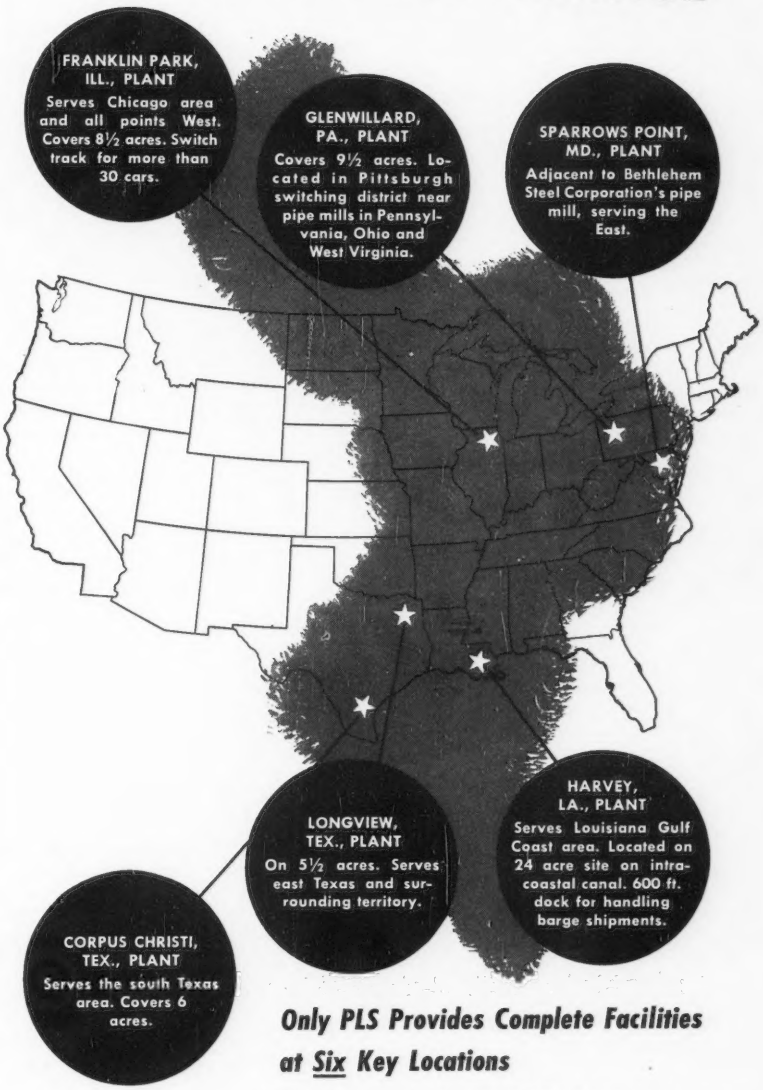
THANKS!

YOUR GUIDE TO BETTER PIPE PROTECTION SERVICE



Only PLS Provides Complete Facilities at Six Key Locations

Pipe Line Service has established complete pipe protection facilities in six locations to meet the varying requirements of pipe users, provide storage space and effect every possible economy for customers. You can send your pipe to any one of these plants with full assurance that it offers you the finest pipe protection your money can buy.

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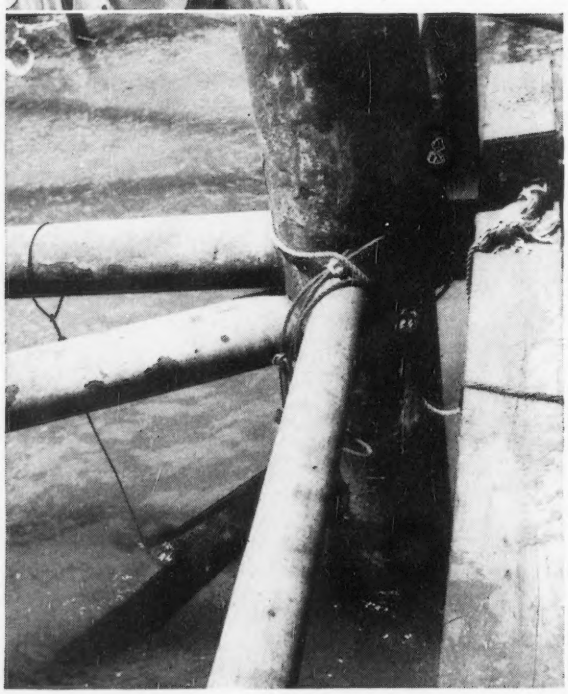
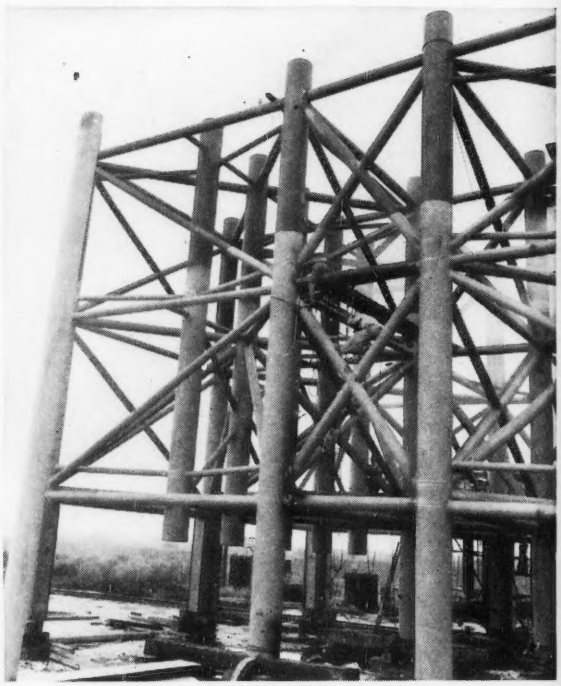
Offshore rigs last longer with "CORO-GARD" Anti-Corrosion Coatings



BEFORE. Only 8 months of normal exposure to salt water spray and immersion caused this conventional coating to fail. Another application will be necessary at once, in order to prevent extreme damage to rig framework and equipment. A costly job that can be avoided.



AFTER. Protective coating of "Coro-Gard" being applied to offshore drilling platform substructures and capbeams. Careful compounding of this synthetic coating guards vulnerable metal against brine, high humidity, petroleum impurities, many other corrosive agents—gives long protection.

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There are 15 basic "Coro-Gard" Coating Systems, each designed for specific service conditions. There's one to meet *your* corrosion or abrasion problem.

WRITE FOR FREE advice on metal conservation problems. Our engineering service will be glad to suggest the proper "Coro-Gard" Coatings. No obligation. Address: Minnesota Mining & Mfg. Co., Adhesives and Coatings Div., 411 Piquette Ave., Detroit 2, Mich.

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ANTI-CORROSION COATING

Made in U.S.A. by MINNESOTA MINING & MFG. CO., St. Paul 6, Minn., also makers of "Scotch" Brand Pressure-sensitive Tapes, "Scotch" Sound Recording Tape, "Underseal" Rubberized Coating, "Scotchlite" Reflective Sheeting, "Safety-Walk" Non-Slip Surfacing, "3M" Abrasives, "3M" Adhesives.

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KAPCO ROCK SHIELD

KAPCO Rock Shield, a newly developed protective shield for pipe and pipe coating was recently subjected to vigorous tests in the rocky terrain of West Virginia. Dense limestone rocks of varying sizes were dropped from a height of five feet directly on the shield. The electronic detector showed no holidays in the coating following these tests. This new protective shield eliminates the need for padding the ditch under rocky conditions and has also been used with a high degree of success at river and road crossings, padding under river weights, pipe anchors and elsewhere where the coating is subject to damage in handling. ROCK SHIELD is available for early delivery in a Midwestern package which includes strapping, ratchet strapping tool and aluminum seals.

* Manufactured exclusively by Keystone Asphalt Products, Chicago, Ill., Division of American-Marietta Co.

For prompt delivery Midwestern maintains warehouse stocks in Tulsa, Oklahoma City, Houston, Kansas City and Newark, Ohio

WRITE MIDWESTERN FOR MORE DETAILED INFORMATION

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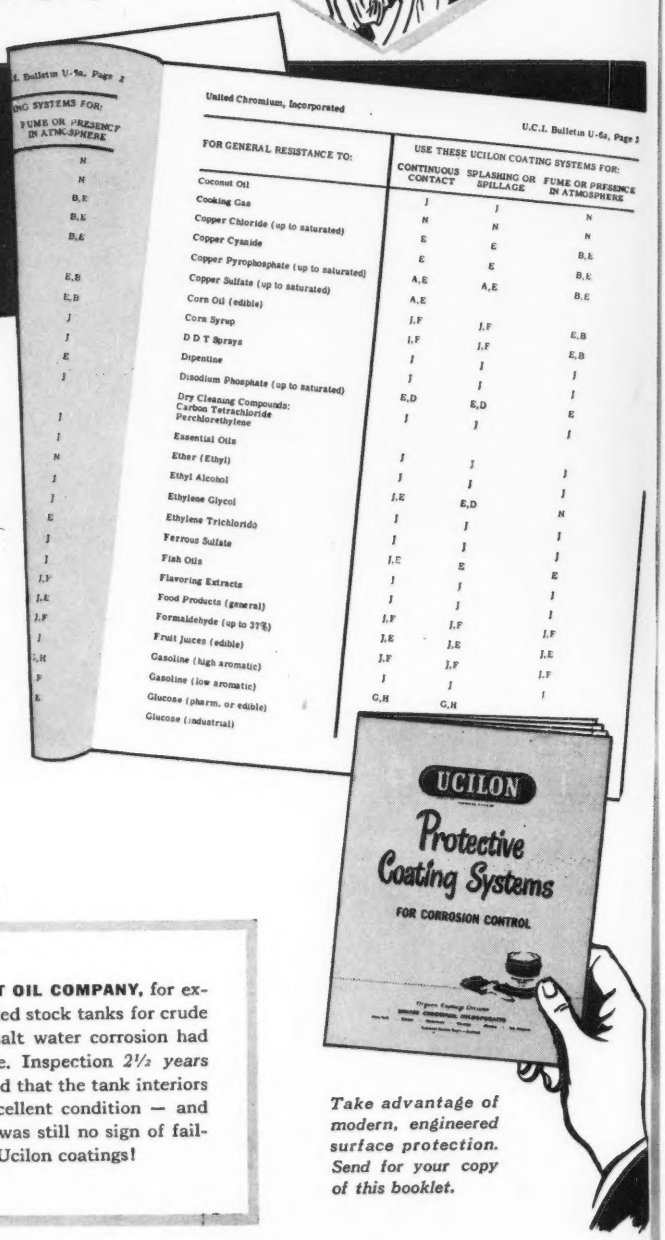
Are your CORROSION troubles listed here?

Control them systematically with UCILON Protective Coatings and the help of this booklet

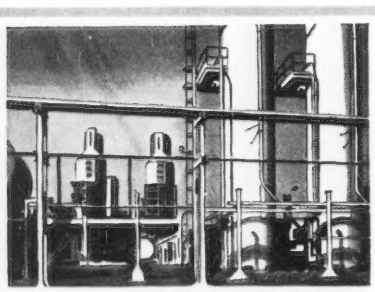


Users of Ucilon coatings are acclaiming this systematic method for controlling corrosion as they report getting longer life from equipment plus lower maintenance costs. It may be the practical answer to your own problem.

First, we send you this 32-page booklet. It lists common agents responsible for failures of ordinary paints and the subsequent corrosion of equipment. For each of the 153 agents listed, it presents a recommended system of Ucilon protective coatings for use against the specific trouble—one which has proved it can lick the corrosion problem to a "standstill." There are systems that resist acids, alkalies, salts, oils, water, organic materials.

You choose the best system for your application, and by so doing you automatically select the required coatings from the complete Ucilon line. Then follow the complete instructions for carrying out the system.

See what a big difference such a systematic approach to corrosion control can make in your plant. You'll learn why Ucilon Systems succeed so often where other coatings fail.



A MIDWEST OIL COMPANY, for example, coated stock tanks for crude oil where salt water corrosion had been severe. Inspection *2½ years* later showed that the tank interiors were in excellent condition — and that there was still no sign of failure in the Ucilon coatings!

Take advantage of modern, engineered surface protection. Send for your copy of this booklet.

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NEW bonding process

- saves time
- saves labor
- saves up to 50% in costs

Corrosion protection is now greatly simplified by new *preformed* Dresser-Bonds and a 5-second chemical welding method that enable any workman to bond mechanical couplings on steel pipelines . . . quickly, easily and at a saving of as much as 50% over previously used bonding methods.

The resistance of the Dresser-Bond is as low as, or lower than, a bond made by any other method. It retains its superior bonding properties permanently because (1) a homogeneous weld area is attained and (2) all surface contact variables are eliminated.

There is no danger of burning the copper wire, pipe or inside pipe coating. No dangerous fumes. No heavy equipment. No training or special skill required. Everything you need for 50 complete bonds is contained in a compact kit which includes *preformed* bonds, chemicals, flint gun and welders.

The neoprene coated 1/0 cable of which Dresser-Bonds are made has been proved for years in underground service.

See the Dresser-Bond installed. Ask your Dresser Sales Engineer to demonstrate it or mail the coupon below for a low-cost trial kit.

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NEW—Completely oil-immersed Selenium Rectifier

LEADERS IN **CATHODIC PROTECTION EQUIPMENT**

for over 20 years

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PROTECT against CORROSION

. . . add valuable years of life and service with B-K packaged units

Brance-Krachy complete package-type protection units include either copper oxide or selenium, air-cooled or oil-immersed rectifiers, underground "trench wire," graphite and carbon anodes and coke breeze backfill. Complete cathodic protection installations sent to your job as a unit. ALCOA magnesium anodes and M. C. MILLER'S MULTI-COMBINATION METERS in stock. We have all accessories for installing any type cathodic protection installation.

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HE WANTED A BETTER METAL FOR HEAT EXCHANGERS

"Our magnesium chloride heat exchangers operate at 50 psi. and average temperatures of 180° F.," said a producer of magnesium. "The air-free solution is circulated at a velocity of 6½ feet a second. Our present equipment suffers from corrosion pitting and stress corrosion cracking."

INCO's Corrosion Engineering Service reviewed all reports on magnesium chloride which were contained in the Corrosion Data File.

A comprehensive summary of this information was sent to the producer. (He later requested additional copies for members of his staff.)

Space limitations make it impossible to give complete details of the summary here.* The principal conclusions drawn were:

1 Corrosion rate of Inconel in relatively air-free solutions of hot magnesium chloride will ordinarily be less than 1 mdd.

2 Inconel is usually not subject to pitting below the liquid level.

3 Inconel is not subject to stress corrosion cracking.

4 In air-free solution under vacuum, Monel showed a corrosion rate of 2 mdd.

5 Ni-Resist and 30% nickel cast iron have sufficient corrosion resistance to be useful materials for pumps and valves.

The producer installed Inconel equipment with considerable success.

**Copies of the full summary, exactly as furnished this producer, are available. If you'd like one, use the coupon at the right.*

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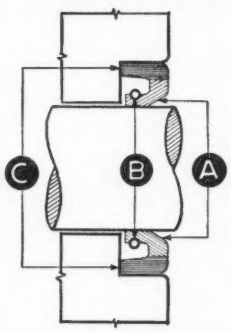

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Corrosion Testing of Buried Cables*

By T. J. MAITLAND*

Abstract

The corrosion testing methods employed in connection with buried toll cables of various types of construction are discussed in detail. The frequency of test points, method of selection, type of instruments employed and the method of analyzing results obtained are outlined. A few typical examples illustrating the results of corrosion tests and the protective measures used to correct unsatisfactory conditions together with the results obtained are given. The necessity for cooperative surveys with other companies having sub-surface structures in the vicinity of proposed or existing buried cables routes is also stressed.

Introduction

THOUSANDS of miles of long distance telephone and telegraph facilities connecting with those of other operating companies of the Bell Telephone System have been placed by the Long Lines Department of the American Telephone and Telegraph Company. This paper discusses but one of the problems confronted in connection with the maintenance of one type of plant used to provide some of the above facilities. The testing procedures outlined are those normally used by the Long Lines Department.

History of Buried Cable Development

The practice of placing telephone cables directly in the earth has been utilized by the Bell System for many years but this method of installing such cables for long distance telephony has expanded enormously during the past ten years. When the first long distance telephone buried cables were originally placed about 20 years ago they were protected against physical damage by means of heavy steel tapes placed over the lead sheath common to all toll cables manufactured at that time. These heavy steel tapes were protected from direct contact with earth by one or more layers of asphalt impregnated jute, and they were also separated from the lead sheath by similar means.

The development of protective coatings for buried cables has been described previously in CORROSION.[1] Further discussion of the various types of coatings now in use will not be given in this paper except as they affect corrosion testing procedures. It should, however, be noted that in connection with placing copper jacketed type cable it was found that in rocky areas sharp rocks occasionally penetrated the copper jacket and weakened the thermoplastic so that lightning would sometimes burn a hole through the lead sheath at such points. To provide mechanical protection in such areas as well as at stream crossings, etc., wire armoring was utilized in place of the copper jacket, retaining the thermoplastic for lightning protection purposes.

Wire armored cables are also used with other than copper jacketed cable at river crossings and at other locations where mechanical damage to the normal sheath protection would be anticipated. Where cables of these types are used on copper jacketed cable routes they are provided with layers of thermoplastic between the lead sheath and the first layer of jute which serves as a bedding for the armor wires. The wires are in turn covered with the usual layers of asphalt impregnated jute to keep them from direct contact with the soil.

Table I gives a rough comparison of the approximate mileage of the various types of cable mentioned above in which the Long Lines Department has an ownership and Figure 1 shows the geographical distribution of this buried cable in the United States.

Corrosion Factors Involved with Buried Cables

In order to maintain this plant in a satisfactory

TABLE I

Mileage of Types of Buried Cable—Long Lines Department January 1, 1949

Type Cable	Sheath Miles	Percent
Tape Armored	855	7.4
Jute Protected	2,975	25.7
Jute-Gopher Protected	2,690	23.2
Thermoplastic Protected	1,510	13.0
Copper Jacketed	3,550	30.7
Total	11,580	100.0

Figure 1—Buried cable routes, long lines department.

* American Telephone and Telegraph Co., Long Lines Department, New York, N. Y.

★ A paper delivered at the Fifth Annual Conference, National Association of Corrosion Engineers, Cincinnati, Ohio, April 11-14, 1949.

condition from a corrosion standpoint several factors must be considered in addition to the usual stray current electrolysis problem. These may be summarized as follows:

1. With tape armored and gopher protected cables a combination of two metals, steel and lead are involved. These metals are connected together at approximately 750-foot intervals with a fairly good conductivity medium between the steel and lead sheath. The steel is protected from direct contact with the soil by its covering of jute, thus giving the equivalent of a coated pipe-line.
2. With plain jute protected cable only lead sheathing is involved. Its protection from the soil may also be considered as approximately equivalent to that of a coated pipe-line.
3. With thermoplastic protected cable in addition to the lead sheath covered with a fairly high resistant coating, copper shield wires are placed in the ground in close proximity to the cable, thus involving a combination of two metals widely separated in the electromotive force series of elements.
4. With copper jacketed type cable two problems are involved, a) where the jacket is kept isolated from the sheath, the equivalent of a thermoplastic covered cable with shield wires, and b) where the bonded type of construction is used, the equivalent of a structure of a combination of two metals, lead and copper, connected together at intervals of approximately 1400 feet.
5. Another problem in connection with the copper jacketed type of construction is the possibility of galvanic couples being set up between the copper jacket and other types of cable to which it may be connected at branch cable junctions, river crossings, underground cable in conduit, etc.

Frequency of Test Points

Most of the buried long distance telephone cables are installed at depths of from 2½ to 4 feet with maintenance points for gas pressure purposes available at approximately ½-mile intervals. At such points it is possible to obtain access to the cable sheath for electrical tests after construction without excavating. These gas pressure test points are, however, the only locations at which the cable sheaths are accessible without laborious excavating work. In this respect testing on buried cable differs from corrosion testing on pipe-lines—you cannot drive a test bar into the ground to make electrical contact with a buried cable and expect to have a serviceable cable left!

At these ½-mile intervals the cable sheath is available for making potential measurements but the current on the cable cannot be measured unless two test connections at known spacings are established to permit a millivolt drop reading to be made. Such current test points are normally provided during cable construction work at approximately five-mile intervals on cables without thermoplastic protection. In addition special currest test points are established at

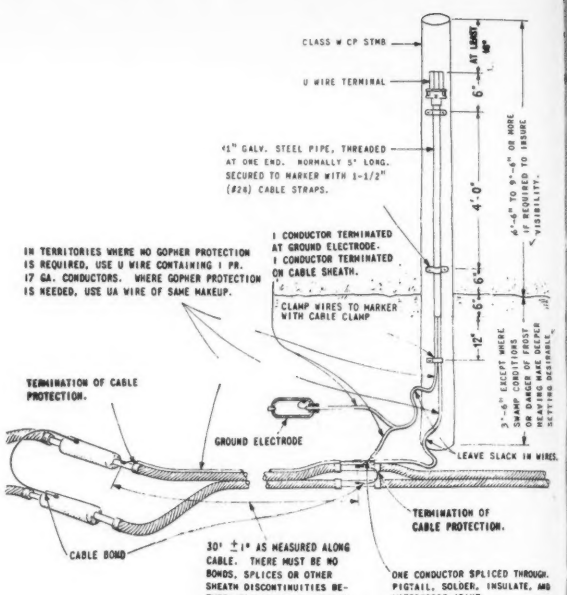

Figure 2—Arrangement at electrolysis test point.

all major pipe-line crossings, railroad crossings, etc. Where pipe-lines or railways operated by direct current or using direct current for signal circuits parallel the cable route within 1000 feet, current test points are installed at each splice location within the parallel and at one-mile intervals where the parallel is between 1000 feet and one mile.

On thermoplastic protected cables the same arrangements are used except that the current test points within a pipe-line or railway parallel are limited to one per mile. Figure 2 shows the arrangement at a typical current test point on the above cables.

On copper jacketed cables current measuring test points are established more frequently because they are used in measuring the leakage resistance of the thermoplastic protection, and are of assistance in locating defects in this material. Where a buried copper jacketed cable terminates or passes through an area in which stray current from electric railway operation may be present, such test points are established at ½-mile intervals within 10 miles of the end of a streetcar line. When the cable is more than 10 miles beyond trolley operation these test points are established at 2-mile intervals except where pipe-lines on which cathodic protection may be applied cross or parallel the cable route within one-half mile. When pipe-lines of the above nature are present, current test points are established at ½-mile intervals for at least two miles each side of the pipe crossing and within the pipe-line parallel. Additional test points also usually are established at junctions with other types of cable on such routes. On copper jacketed cable routes where the jacket is isolated from the sheath a test lead connected to the copper jacket is installed at each gas pressure valve point to provide access to the copper jacket for potential and resistance measurements because the cable construction

is such that the jacket is not otherwise available. These test leads also act as lightning protection wires for the markers carrying the gas pressure equipment and hence are terminated on the marker posts in a different manner than that used on other types of buried cable. The arrangement used at current test points on copper jacketed cable is shown in Figure 3.

Selection of Buried Cable Routes

In connection with the selection of buried cable routes for toll cables, consideration is given to the corrosion possibilities of soil characteristics, effect of other subsurface structures, electric railways, etc. Although these items are given special consideration, other factors may necessitate locating the cable in areas where corrosive conditions may be present for which special measures are required in connection with the cable construction to insure that serious detriment to the cable will not result.

In studying soil characteristics on a proposed buried cable route, earth resistivity measurements are made at predetermined intervals along the route, and the experience of utilities and pipe-line companies having buried plant, if any, in the vicinity of the proposed route is obtained in order to determine the desirability of installing special coatings on the cable. In some instances it has been found desirable to change the proposed location of the cable to avoid certain areas having known corrosive effect on lead or steel or to eliminate the necessity for a special corrosive resistant coating. Where the cable route must parallel or cross electric railways, or be placed in the vicinity of ground beds used for cathodic protection of pipe-lines, special effort is made to insure that any necessary corrosion mitigative measures will be provided for the cable as soon as practicable after it is placed.

After the cable route has been selected and before the cable is placed, the route is traversed with a pipe-line locator to ascertain the exact location of any metallic structures along the proposed route, in order that special precautions may be taken to avoid damage to these structures during the cable placing work. With the location of these structures with respect to the cable route ascertained in so far as practicable, the owners of the structures are consulted with regard to the corrosion protection arrangements employed on their structures. To provide permanent test points along the cable at or near crossings or parallels with structures on which cathodic protection may have been employed or is anticipated, the owners of the structures are invited to cooperate in establishing test connections for the mutual benefits to be derived from such installations. A method of establishing such test points which has generally been found satisfactory is shown in Figure 4.

This arrangement permits measurement of: 1) current on the cable each side of the crossing with the other structure, 2) the potential of the cable with respect to the other structure, and 3) the potential of both the cable and structure to earth. In some instances it has been found that the company owning the other structure desires to establish test connections in a different manner, particularly where it has developed a standard test point arrangement. Such test points are considered entirely satisfactory provided arrangements are made to permit access to the test connections by either party for tests between the two structures at periodic intervals as may be required by their respective maintenance instructions.

Testing Methods

In general, two factors are considered in the corrosion testing of buried cable: 1) the current (amount and direction) on the cable, and 2) the potential of

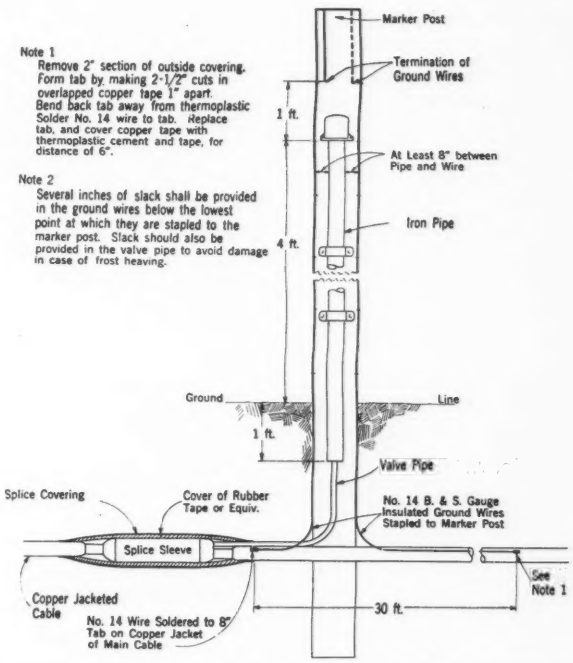

Figure 3—Arrangement for electrolysis testing on copper-jacketed cable.

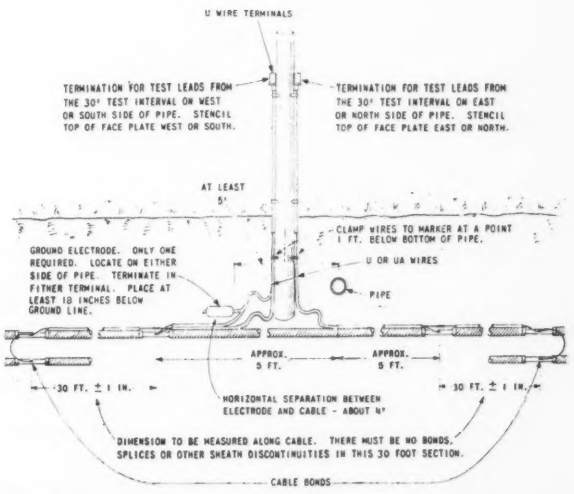

Figure 4—Arrangement of electrolysis test point at pipe line crossing.

the cable with respect to earth. Where pipe-lines are present in the vicinity of the cable route a third consideration is also brought into the picture, the potential between the two structures. Where thermoplastic covered cable is employed the leakage resistance of the thermoplastic also becomes a factor in protection of the sheath against corrosion.

Where measurement of the current on a cable shows no appreciable loss between test points and the potential of the cable with respect to earth is negative, corrosion conditions are classified as satisfactory. In measuring the potential to earth several factors must be taken into consideration: 1) the location of the electrode used for earth contact, 2) the metallic composition of the structure being tested, and 3) the material used for the electrode.

For measuring potentials between cable and earth it has been found that a high sensitivity voltmeter generally is required because of the high resistance contact encountered in the ground electrode. It also has been found very desirable to employ a high resistance millivoltmeter with a full scale reading of 1.0 millivolt or less for measuring the voltage drop (current) along the cable, correcting the millivoltmeter readings for the test lead resistances if necessary.

Tests on Non-Copper Jacketed Cable

For measurements on non-copper jacketed type cables it has been found that the use of a permanent ground electrode consisting of a short section of the cable sheath material placed in the ground a short distance from the cable as shown in Figure 2 is quite reliable. Measurements to such electrodes have compared favorably with those made to lead chloride half cells which are employed when measurements are made at locations where these permanent ground electrodes are not installed. The installation of corrosion protective measures is not usually considered necessary unless there is evidence of appreciable current loss between adjacent test points, or evidence of some local condition which may result in positive cable-to-earth readings in excess of .10 volt. When it is necessary to apply cathodic protection a potential of approximately .20 volt negative to earth is considered desirable. Near the point of application of drainage the potential to earth may of necessity be as high as .50 volt negative.

Tests on Copper Jacketed Cable

For cables of the copper jacketed type it has been found desirable to employ a copper sulphate half cell for cable-to-earth potential measurements or to install permanent ground electrodes of copper sheeting. Copper sulphate half cells also are used for measuring the cable-to-earth potential on wire armored cable lengths on copper jacketed cable routes. It is considered that a negative potential between copper jacket and ground plate or copper sulphate half cell greater than .25 volt represents a satisfactory condition. For wire armored cable a negative potential value of more than .70 volt is considered sufficiently satisfactory to not require the installation of protective measures.

Because the presence of two metals, widely separated in the electromotive series, in close proximity in an electrolyte always introduces the possibility of corrosion from galvanic action, special attention has been given to this feature in connection with the use of shield wires or the copper jacket covering with lead sheathed cable. Where shield wires are present along a cable route indication of appreciable current on the cable at a test point is considered worthy of investigation to determine if these wires are the cause of this current. In several instances they have been found to be the culprits.

In the case of thermoplastic protected cables either with or without a copper jacket of the non-bonded type construction, resistance measurements of the insulation afforded by the thermoplastic have been found desirable. Where such measurements show the presence of low insulation an investigation is made to determine the cause and correct the situation if practicable.

Use of Cathodic Protection

When because of local conditions it is not found practicable to correct the low insulation by reinsulating the sheath such as in the case of gopher or termite attack, cathodic protection measures are applied. Similar measures also may be applied where tests indicate an appreciable current loss or where positive potentials have been observed between cable and earth which cannot be dealt with economically by other means.

Two types of cathodic protection have been utilized to date for protection of buried cable: 1) distributed anodes of zinc or magnesium and 2) forced drainage using rectifiers and current-carrying grounds. In general, the use of galvanic anodes has proved most satisfactory for cables with thermoplastic protection, because the potential introduced by the use of rectifiers may result in electroendosmosis near the points of application.

Typical Experiences with Cathodic Protection Systems

Extensive installations of galvanic anodes for protection of buried cables have been limited to date on long distance cables to two areas: 1) west of Salt Lake City, Utah, using zinc anodes as described in a previous paper,[2] and 2) between Overton and Ogallala, Nebr., where magnesium anodes are employed.

The effect of the zinc anode installations on the cable-to-earth potentials west of Salt Lake City as determined from a survey made during July, 1948, are shown in Figure 5 together with a comparison of the effect on these potentials as originally obtained by this protection system in 1944. This protection has been in place for over four years and the most recent survey indicates that it is, in general, operating effectively. It was, however, found desirable to supplement the existing protection with additional anodes at two locations where tests showed the cable

to be less negative to earth than considered desirable.

Comparison of recent data with that originally obtained on this protective installation is shown in Tables II and III.

In order to determine the condition of the anodes after four years of service one of them was dug up and inspected. Selection of the anode for inspection was based primarily on the data shown in Tables II and III. This anode was one which was buried in the Bonneville Salt Flats and was expected to show considerable corrosion because it had produced over 500 ampere hours of current. Upon investigation it was found that the zinc bar had lost approximately 1¾ pounds, thus giving a corrosion efficiency of 130 percent if no deduction is made for self corrosion. The bar was covered with a heavy white coating which upon handling chipped off exposing the pure zinc. From the measurements obtained it is believed that the salt coating had caused the zinc to become at least partially passivated, although the current delivered by the bar had dropped only a few mils during its period of service. Figure 6 shows the appearance of the zinc bar after removal as compared to a new bar.

In the Overton-Ogallala area magnesium anodes were installed at intervals of from two to three miles depending upon requirements as determined by cable-to-earth potential measurements and sheath-to-earth resistance measurements using formulas described previously.[3]

A total of 41 anode locations in the 120-mile area were initially involved in this installation, from one to four anodes being used at each location depending on local requirements. The anodes supplement the forced drainage systems originally utilized in this area which were found to be insufficiently effective due to gopher damage to the protective covering over the steel tape on the cables.

Because installation of these magnesium anodes was completed during the latter part of 1948 results of their effectiveness throughout the entire area are not yet available. Initial results for the anode installations on cable-to-earth potentials in the North Platte-Ogallala section of the cables are, however, shown in Figure 7 together with data for each of these anode installations.

Forced drainage systems employing rectifiers and special current carrying (made) grounds have been installed at a number of locations on long distance buried telephone cables with satisfactory results from a corrosion protection standpoint. The magnitude of the negative cable-to-earth potentials encountered near the point of application of forced drainage to the cable is frequently greater than desirable with the result that electroendosmosis may occur in the protective coatings. For this reason the application of such protection has been used in relatively few instances where local conditions are such that this type of protection is considered more economical than other measures.

A typical example of the effect of rectifier drainage is shown by Figure 7 in which the initial effect on cable-to-earth potentials produced by drainage at two locations approximately 17 miles apart in the North Platte-Ogallala area may be compared with that obtained by use of magnesium anodes using the same total current. It is believed that these results tend to substantiate the data recently published[4] indicating that to protect a given area, small units properly spaced will require less total current than large units spaced at greater intervals.

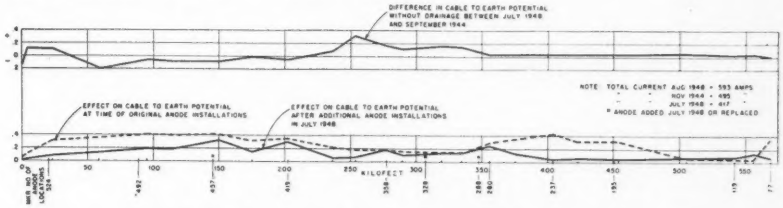

Figure 5—Salt Lake City—Wendover cables. Effect of zinc anodes.

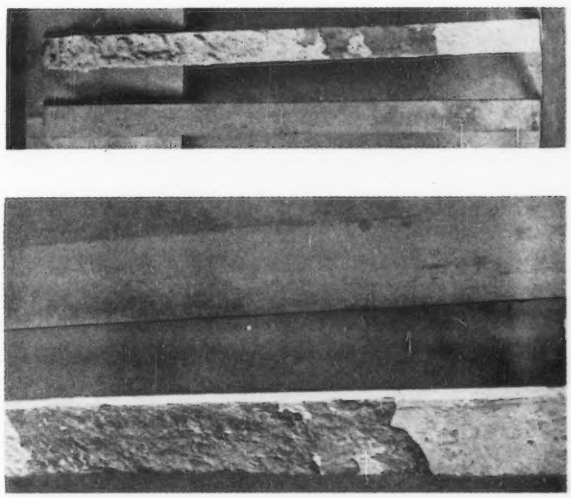

Figure 6—Comparison of New and Used Anodes.

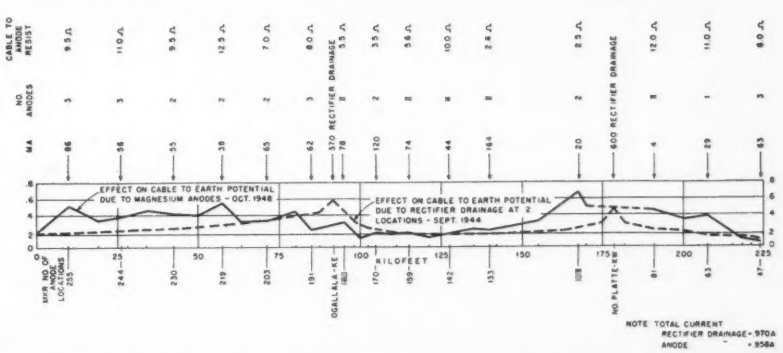

Figure 7—North Platte-Sidney cables. Effect of magnesium anodes and effect of rectifier drainage.

TABLE II

Anode Location	CURRENT DRAINED—Amperes			
	Nov., 1944	Nov., 1945	July, 1948	Aug., 1948
Marker 77	.080	.030	.030	.033
Marker 119	....	‡.050	.029	.028
Marker 195	.100	.050	.040	.033
Marker 237	.020	.050	.059	.052
Marker 280	.035	.060	.103	.086
Marker 288	....	....	....	†.052
Marker 328	....	....	....	†.068
Marker 358	.020	.035	.062	.057
Marker 419	.030	.035	.026	.005
Marker 457	.020	.020	.015	*.128
Marker 492	.030	.010	.024	.018
Marker 523	.100	.030	.029	.033
Total	.495	.370	.417	.593

* Anode Replaced July, 1948.
† New Anodes Added July, 1948.
‡ Anode Added November, 1945

Anode Location	Effect on Cable-to-Earth Potentials—Volts			
	Nov., 1944	Nov., 1945	July, 1948	*Aug., 1948
Marker 77	0.34	0.20	0.08	0.06
Marker 119	0.04	0.22	0.10	0.07
Marker 195	0.31	0.14	0.02	0.02
Marker 237	0.42	0.27	0.14	0.14
Marker 280	0.29	0.14	0.05	0.24
Marker 288	0.22	....	.04	0 13
Marker 328	0.15	....	.07	0.07
Marker 358	0.18	0.17	0.15	0.18
Marker 419	0.36	0.36	0.09	0.30
Marker 457	0.40	0.40	0.10	0.32
Marker 492	0.40	0.34	0.15	0.19
Marker 523	0.30	0.10	0.10	0.08

* Approximately one month after new anodes added at Markers 288, 328 and 457.

TABLE III

Location	CABLE-TO-EARTH RESISTANCE			
	Oct., 1944	Apparent Resistance Nov., 1944	July, 1948	Apparent Resistance Aug., 1948
	Ohms	Ohms	Ohms	Ohms
Marker 77	1.10	4.25	1.00	1.82
Marker 119	....	....	.75	2.50
Marker 195	.78	3.60	.55	.61
Marker 237	.60	25.00	.42	2.70
Marker 280	1.45	5.72	.88	2.90
Marker 288	....	....	1.08	2.50
Marker 328	....	....	1.20	1.03
Marker 358	2.02	9.00	1.35	3.16
Marker 419	.88	12.00	1.30	60.00
Marker 457	1.00	20.00	1.15	2.50
Marker 492	1.20	13.30	1.20	10.50
Marker 523	1.00	3.00	.60	2.42

Location	Anode-to-Earth Resistance		Potentials	
			Anode-to-Earth	Cable-to-Anode
	Nov., 1944 Ohms	July, 1948 Ohms	July, 1948 Volts	July, 1948 Volts
Marker 77	1.60	3.80	—.404	+.320
Marker 119	....	‡9.10	—.469	+.535
Marker 195	1.70	5.00	—.448	+.444
Marker 237	1.05	1.82	—.432	+.409
Marker 280	5.80	2.54	—.422	+.522
Marker 288	....	†9.40	—.374	+.535
Marker 328	....	†5.00	—.290	+.530
Marker 358	7.00	4.00	—.419	+.570
Marker 419	1.30	3.50	—.428	+.388
Marker 457	1.25	*1.12	*—.253	*+.133
Marker 492	1.55	1.42	—.440	+.298
Marker 523	1.25	2.05	—.400	+.343

* This anode was replaced July. 1948—new anode to earth resistance measured 0.25 ohms. Potential—.560 volts and cable to anode potential +.440 volts.
† New anodes added July, 1948.
‡ Anode added November, 1945.

Cooperation With Other Utilities

In the application of cathodic protection measures to a buried structure the necessity for cooperating with owners of other structures in the vicinity of the structure which it is planned to protect should be given first attention. The necessity for such cooperation is given particular emphasis in connection with the establishment of cathodic protection measures on long distance telephone cables, and invitation is extended to known owners of other structures which are present in the vicinity of proposed protective measures to participate in tests to determine the effects of such measures on their plant. In event the effect of a proposed measure is found to be detrimental, arrangements are made to modify it in so far as practicable to establish the best engineering solution satisfactory to those concerned.

Most of the long distance telephone buried cable routes are located in open country so that joint committees established to correlate corrosion control measures in cities and suburban areas are but little interested in such situations. The necessity for cooperative work is, however, definitely a factor in providing mutual satisfactory conditions from a corrosion standpoint on buried cable and pipe-line plants and it is considered that such cooperative measures are of particular importance from the standpoint of corrosion control for all buried structures.

Conclusion

Although corrosion experience to date with buried cable has been very favorable, the rapid increase in the amount and diversity of the types of cable used introduce problems which necessitate constant vigilance. It is believed that routine testing of such cables on an annual basis is well worth the time spent for assurance that no unsatisfactory conditions develop which would cause rapid deterioration of the cable sheath.

References

1. V. J. Albano and Robert Pope, "Protective Coatings on Bell System Cables." *Corrosion*, **3**, 221-226 (1947) May.
2. T. J. Maitland, "Corrosion Protection for Transcontinental Cable West of Salt Lake City, Utah." *Corrosion*, **1**, 47-58 (1945) June.
3. J. M. Standring, "Attenuation of Drainage Effects on a Long Uniform Structure with Distributed Drainage," *Corrosion*, **3**, 301-309 (1947) June.
4. E. P. Doremus, W. L. Doremus and M. E. Parker, Jr., "Attenuation Equations Applied to Cathodic Protection by Distributed Drainage." *Corrosion*, **5**, 32-36 (1949) Jan.

DISCUSSION

Comment by Dr. W. Beck, Lehigh University, Bethlehem, Pa.:

Besides the type of instruments described by Dr. Maitland, the writer has applied a special technique to the measurement of stray currents and cable-to-earth potentials.

A galvanometer device was used containing a very light loop of aluminum in place of a pointer.

The sensitivity of this instrument is extremely

high, the resistance of the aluminum foil very small. The oscillations of the loop in a stray current field are recorded on photographic film. Oscillograms of stray currents taken at various sections of pipe and cable lines were shown by the writer.

The measurements were taken with the aid of an auxiliary electrode of special construction. Investigations with regard to electrolytic corrosion of pipes and cables and examples of the application of the loop galvanometer to the measurement of corrosion currents are scheduled to be published in the near future.

Author's Comment:

The instruments described in the paper "Corrosion Testing of Buried Cables" are those which are normally available for corrosion testing work by maintenance personnel. Where the results of tests made with such instruments show the presence of a situation requiring special investigation, other instruments and special techniques are frequently employed to assist in the solution of a specific problem. The use of such instruments and their application to special problems are not considered to be within the scope of this paper.

The development of suitable instruments for practical field application in the solution of corrosion problems is one which it is believed all corrosion engineers are interested. If the experience of Dr. Beck with use of a special galvanometer in the practical solution of corrosion problems involving pipe lines and cables can point the way to a suitable method of obtaining the answer to such problems with a minimum amount of field investigation it will be of valuable assistance to the corrosion protection engineers.

Comments by Daniel R. Werner, American Telephone and Telegraph Company, Long Lines Department, Chicago, Illinois:

These comments concern that part of the paper referring to the installation of magnesium anodes in the 120-mile buried cable section between Overton and Ogallala, Nebraska, where the two cables are thermoplastic covered.

As mentioned in the paper, a total of 41 anodes were installed at 2- to 3-mile intervals. These anode installations were made at points where existing valve pipes for pressure testing were connected to the cable and brought out above ground on marker posts at approximately ½-mile intervals. The magnesium anode installations thus had to be placed at specific points which were governed by the spacing of these valve pipes. The resistance of the anodes to earth at each location had to be tailored to meet the desired change in cable-to-earth potential to give a negative cable-to-earth potential of about 0.3 volt.

Preliminary measurements consisted of making measurements of the cable-to-earth resistance and cable-to-earth potential at one-mile intervals. From

TABLE I

Marker No. of Anode Location	Number Installed	Anode No.	Depth Feet*	Separation Feet	Earth Resistivity Meter-Ohms to Depths of 5′	10′	20′	Anode-to-Earth Resistance Ohms
47	3			10	32.6	67	57.5	5.4
		1	4					15.4
		2	4					12.9
		3	4					19.4
63	1		4‡		22.5	35	53.7	10.2
81	3			10	64	119.5	162	10.7
		1	4					28.7
		2	4					25.7
		3	4					28.7
109	2			10	25	34.5	42.2	7.7
		1	4‡					12.7
		2	4‡					14.2
133	2			10	6	5.75	7.6	1.45
		1	4‡					2.6
		2	4‡					3.1
142	4			10	44	47	49	8.9
		1	7					28.4
		2	5					38.9
		3	5					33.9
		4	7					33.9
159	2			10	28.8	28.8	26.8	4.7
		1	5					8.6
		2	5					8.1
170	2			10	8.15	13.45	21.12	3.0
		1	4					4.5
		2	4					8.0
180	2			10	18.2	22	17.2	5.0
		1	8					9.5
		2	8					9.5
191	3			10	157	61	57	6.9
		1†	16					16.9
		2	14					20.9
		3	13					16.6
203	2			10	127	67	38	5.6
		1	13‡					10.1
		2	13‡					11.1
219	2			10	50	45	84	9.0
		1	8					16.0
		2	8					16.5
230	2			10	78.2	90.0	38	7.7
		1	10					14.2
		2	10					14.7
244	3			10	72	44.2	38	8.8
		1†	10					22.8
		2†	10					15.8
		3†	10					32.8
255	3			10	92	59	61	7.9
		1†	10					
		2†	10					
		3†	10					

* Depth to bottom of hole 6 inches in diameter.
† One quart sodium sulphate added to slurry poured in on 1-B Galvopak.
‡ Natural ground water came up over 1-B Galvopak.

these measurements, calculations were made to determine what cable-to-earth voltage change might be expected for spacings between anode installations of 0.5, 1.0, 1.5, 2.0, 2.5 and 3 miles and for resistances to earth at each anode installation of 5 and 10 ohms.

A Biddle four-range ground resistance megger was used to measure the cable-to-earth resistance using the 3-point method and resistances of 0.5 to about 2.2 ohms were obtained. The resistance looking in either direction along the cable from the point of measurement for practical purposes was assumed to be twice these measured values to determine the kilo-foot-ohms leakage resistance and the attenuation factor for the purpose of application to formulas developed by Mr. Standring. (See Reference No. 3.)

A Weston 200,000-ohm-per-volt voltmeter and lead chloride half cell was used to measure the cable-to-earth potentials.

At each location selected for installing magnesium anodes, measurements were made of the earth resistivity for depths of penetration of 5, 10 and 20 feet using the Biddle four-range megger. The earth resistivity was found to vary over wide ranges at various depths and these earth resistivities were used as a guide to determine how deep a hole should be dug

for the magnesium anodes. As the holes were being dug, samples of the earth were placed in a decimeter cube box having stainless steel end plates and the resistance of the sample was measured with a megger between these plates. Where the samples of earth were not wet, the resistances thus measured could be used as a criterion to determine when the lowest resistance strata was reached. As an example, at one location the earth resistivity was found to be 78.2, 90 and 38 meter-ohms at penetration depths of 5, 10 and 20 feet, respectively. Borings showed high resistance sand down to a depth of about eight feet where a strata of low resistance clay-bearing sand about 18 inches deep was found and the magnesium anodes were centered in this strata giving the desired results.

Table I shows the depths anodes were placed in the section covered by Figure 7, together with the earth resistivities measured at depths of 5, 10 and 20 feet and the anode-to-earth resistances obtained.

The earth resistivities were determined to various depths of penetration from the formula (1) using the four rod method.

$$\text{Earth resistivity in meter-ohms} = 1.92\ SR \qquad (1)$$

Where R = Ohms resistance measured with the megger (current leads connected to rods 1 and 4 and potential leads connected to rods 2 and 3 properly phased).

S = Separation between four equally spaced rods in feet placed in a straight line and driven in the ground a depth of not over S/10 feet.

The earth resistivity obtained by the above method is the average resistivity through a horizontal half cylinder section of earth with a radius equal to the spacing S of the rods. At the earth's surface, the half cylinder is 2S wide and the depth of penetration is equal to the radius S of the semicircular section below the earth's surface. The earth resistivity obtained for different depths of penetration is thus an average because the area of the semicircular section is not proportional to the different depths of penetration.

Corrosion and Protection of Mine Hoist Ropes ★

By F. L. LaQUE*

Introduction

Corrosion as a factor determining the life of mine hoist rope has been the subject of some recent intensive studies in Canada. Representatives** of the company with which the author is associated have had the privilege of being closely connected with these investigations and through their courtesy the author has had an opportunity to review the records and procure photographs and photomicrographs to illustrate this paper. They also have cooperated fully in the preliminary tests of protective oils and greases. Much of the information to be reported here was included in technical papers in Canada and, in particular, in a paper by R. E. Dye[1] entitled "Hoisting Rope Research in Ontario Mines by The Committee on Hoisting Ropes—The Ontario Mining Association" presented before the Canadian Institute of Mining and Metallurgical Engineers, Vancouver, in in April, 1948.

The appearance of the corrosion that is the subject of this discussion is shown by Figure 1.

History of Investigation

THE STUDY of the general problem upon which this discussion is based started immediately after the failure of a hoisting rope on a man cage in a small gold mine in Ontario. This failure resulted in the death of several miners and precipitated an extensive program of research into the causes of the break and means of avoiding similar failures in the future. Part of this program was concerned with studies of the nature of the corrosion that occurs, its distribution through a rope, its location along the length of a rope, the extent of damage and means of preventing or reducing corrosion by improved lubricants and methods of application.

Construction of Hoisting Ropes

As an aid to the better understanding of the problems involved, the construction of a typical hoisting rope is shown in Figure 2. It is known as a round strand Lang's lay rope made up of six strands of 19 working wires with six filler wires. The wires surround a central fiber core which functions to support the strands and make the rope flexible by permitting movement of the strands.

These fiber cores are always treated with mineral oil added up to about 25 percent of the weight of the core as a preservative of the core—not as a reservoir

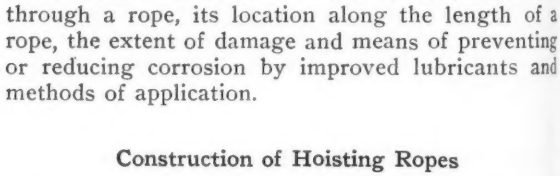

Figure 1—Underside of strand from severely corroded rope showing pitting of the wires. (Magnification X 2½)

★ A paper presented to the New York Section of the American Society of Lubrication Engineers, Nov. 4, 1948, at New York. Printed with permission of the society.

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** Especially R. D. Parker, general superintendent, The International Nickel Co. of Canada, Ltd. and his assistant, P. I. Ogilvie.

of oil for lubrication of the wires as is sometimes erroneously believed.

Ordinarily, the grease in the core tends to protect the wires from corrosion, but occasionally the grease becomes acid and causes some corrosion of the wires in contact with the core. Although this should not be considered to be a major factor in corrosion of hoisting ropes under ordinary circumstances, it would appear to be desirable to minimize the corrosive characteristics of the greases used to treat core fibers —as by the addition of anti-oxidants, neutralizers of acidity or corrosion inhibitors. Furthermore, the amount of grease applied should be ample to last the desired life of the wire since there is no opportunity to replenish it in service.

During the process of manufacture of the ropes the wires are treated with greases for lubrication and protection. It is suggested that the greases used at this stage should be chosen so that they will be as compatible as possible with the dressing to be applied to the rope in service.

Nature of Steel

The steel used for hoisting rope wire is of a special quality carbon steel coming within the following range of analysis:

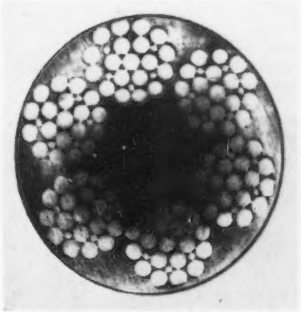
Carbon	0.75-0.85%
Silicon	0.15-0.30%
Manganese	0.40-0.70%
Phosphorus	0.05% max.
Sulfur	0.05% max.

It gets its strength from a combination of heat treatments (patenting) and cold drawing and throughout the course of its processing it is handled with more care than is required for wire for less critical applications. The tensile strength of the wire generally exceeds 220,000 lb. per sq. in. and may be as high as 280,000 psi.

It is not at this time considered to be practical to provide a corrosion resisting metal or alloy that will have the high strength required for this service. The non-ferrous metals and alloys fall short of the required tensile properties. Certain stainless steels can be cold worked to the strength level needed, but up to now these heavily cold worked materials are not considered to be reliable enough for the service; principally because of uncertainties as to the stability of their tensile and torsional properties and their retention of the required ductility when subjected to further cold work in service.

The use of weaker materials is prevented, of course, by the fact that the diameter of the rope is fixed by the characteristics of each installation with respect to such details as the diameters of the grooves in the sheaves and drums over which the ropes must pass. Presumably it would be possible to design a new installation to accommodate the larger diameter of a weaker rope made of corrosion resisting alloys, but it does not seem likely that this will be done so long as there is a reasonable chance of being able to protect the high strength carbon steel ropes by the proper choice and application of protective oils and greases. It is on this latter basis, therefore, that the problem of preventing corrosion of wire ropes is being attacked.

A—1¾-inch diameter Lang's lay rope with one strand removed to show the core.



B—Section of a 1¾-inch diameter hoisting rope showing details of construction and arrangement of wires in the strand. (Magnification X 2½)

Figure 2

It should be noted, however, that in some mines where the water is neutral or slightly alkaline, zinc coatings may provide excellent protection and are being employed in some instances. Most other metallic coatings are more noble (cathodic) than steel and would be expected to cause accelerated corrosion at any breaks in such coatings.

So far, plastic coatings have not been able to withstand the severe abrasion associated with the relative movement between wires during use of a rope.

Distribution of Corrosion Along a Rope

The distribution of corrosion along the length of a hoisting rope is a matter of great uncertainty. There has been some belief that deterioration was likely to be most pronounced near the skip of cage end of the rope, but this has not been borne out by systematic studies of 73 ropes from different mines in Ontario. Amongst these ropes, all but four suffered the greatest reduction in strength in the section within the shaft when the cage was at the bottom. In only six cases was the deterioration most pronounced near the cage or skip. It follows then that the practice of periodic inspection and testing of pieces cut from the cage end of a rope does not necessarily disclose the extent of weakening that may be occurring elsewhere along its length.

Figure 3 shows the distribution of deterioration along the length of the rope that failed and precipitated the present investigation.

Figures 4 and 5 shows the location of severest damage on ropes typical of ones subjected to heavy wear and severe internal corrosion.

Figure 6 shows that the weak points in a sequence of ropes used on the same hoist, but not at the same time, do not necessarily occur at the same place.

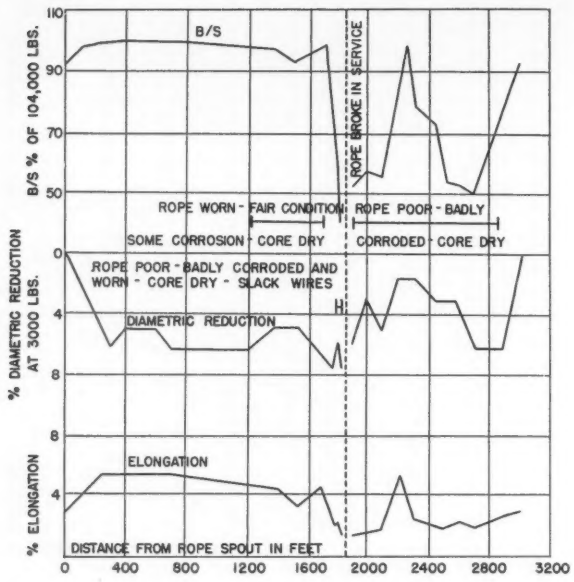


Figure 3—Graph of 1-inch in diameter hoisting rope which failed in service because of severe internal corrosion. The rope had been in use for 912 days.

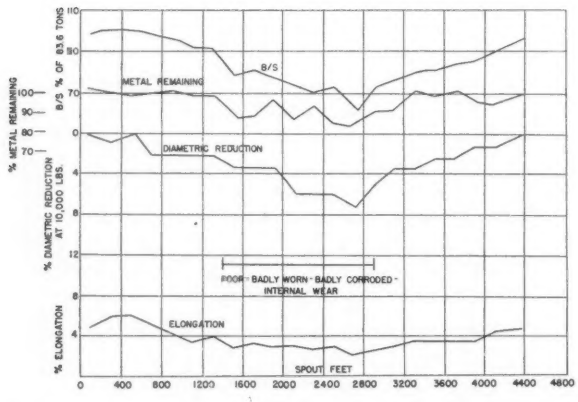


Figure 4—Graph of a 1½-inch diameter skip rope. The curves are typical of a rope that has been subjected to heavy wear and severe internal corrosion.

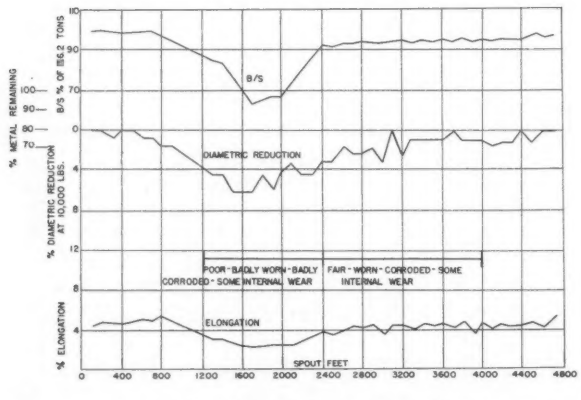
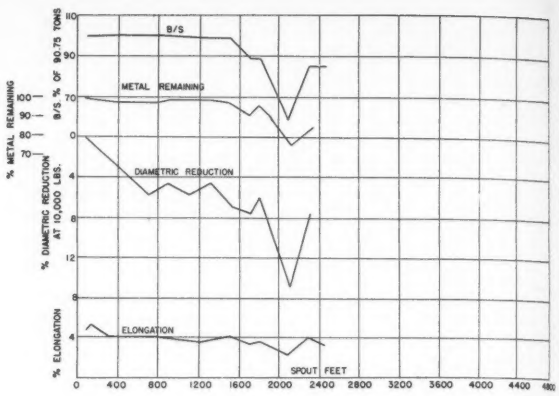


Figure 5—Graph of a 1¾-inch diameter cage rope weakened by wear and severe internal corrosion.



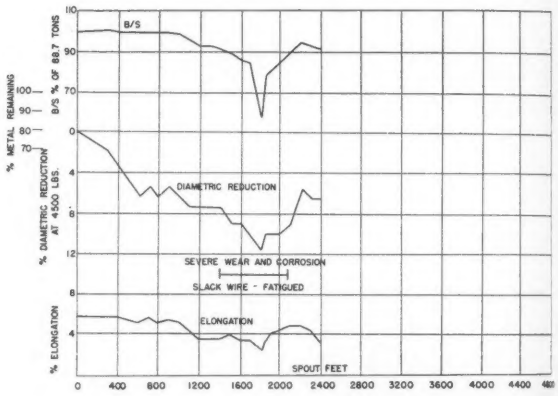


Figure 6—Graphs of 1⅜-inch diameter skip ropes which followed one another on the same hoist. The curves are similar but weak point does not occur at the same place in the ropes.

Figure 7 similarly indicates that the weak points occur at the same place in ropes used simultaneously on the same hoist.

Nature of Deterioration

The progress of deterioration by corrosion is illustrated by photographs of cross sections of a single rope at different points in Figures 9 and 10. An enlarged view of a section at a point where corrosion had reduced strength by 34 percent is shown in Figure 11.

The pattern of corrosion of a typical wire is shown in Figure 12, and of a number of wires in Figure 13.

The mechanism of corrosion of the inner wires is believed to involve an oxygen concentration cell or differential aeration cell effect. The water that manages to seep into the rope through the outer layer of grease and rust contains relatively little dissolved oxygen as compared with the water in contact with the freely exposed outer surfaces of the wire. The steel in contact with the water deficient in dissolved oxygen becomes the anode of an oxygen concentration cell. The corrosion products are generally magnetic and consist principally of magnetite with some ferrous hydroxide and a small amount of a hydrated ferric oxide.

Failure of wires by the ordinary processes of fatigue is a rarity, presumably because the cyclic

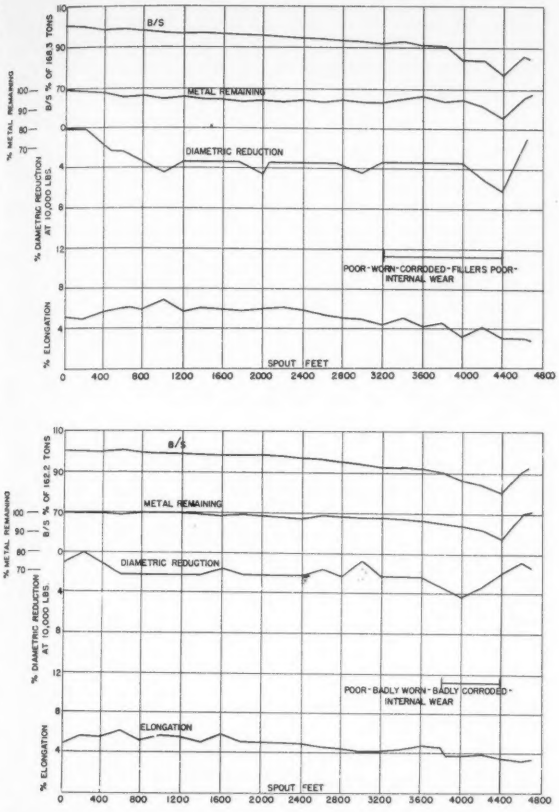
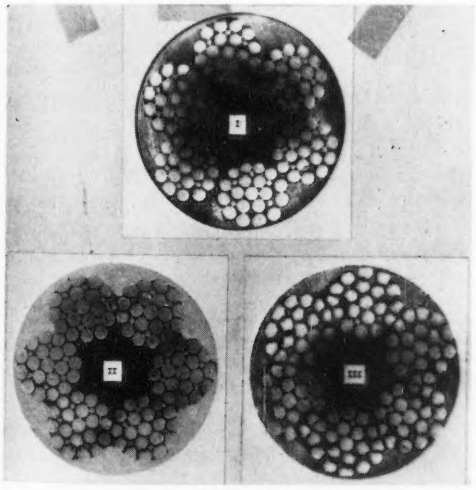


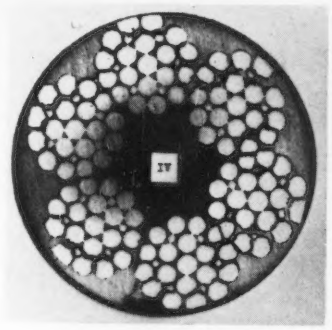
Figure 7—Graphs of 1¾-inch diameter skip ropes used simultaneously on the same hoist. The weak point occurs at the same place in both ropes.



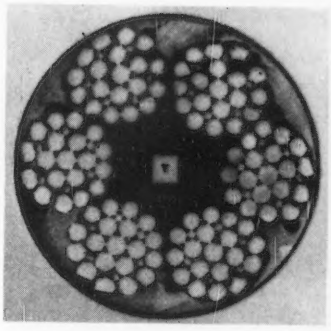
Section I—Cut 700 feet from drum spout. Shows only slight wear and no corrosion. No reduction in breaking strength.
Section II—Cut 1200 feet from the drum spout. Shows wear and corrosion. Breaking strength reduced by 15 percent.
Section III—Cut 1600 feet from the drum spout and near the weak point in the rope. Shows severe internal corrosion. Breaking strength reduced by 34 percent.

Figure 8

stresses such as induced by bending over sheaves and drums are a small fraction of the fatigue strength of the wires. Furthermore, corrosion fatigue is encountered much less than might be anticipated from the extent of

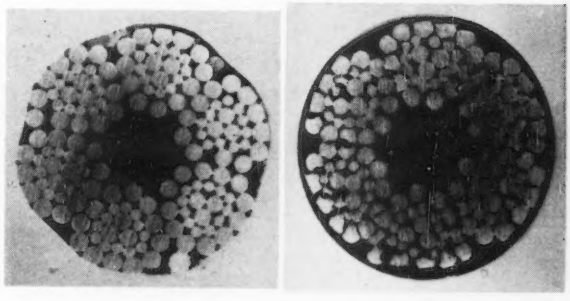


Section IV—Cut 220 feet from drum spout. Shows well developed corrosion. Breaking strength reduced by 21 percent.



Section V—Cut 2400 feet from drum spout. Shows some corrosion. Breaking strength reduced by only 9 percent.

Figure 9



A B

A—This section cut 760 feet from the drum spout. Shows some wear but no corrosion. There was no decrease in strength at this point.
B—This section cut near the point at which the rope failed. Shows severe wear and internal corrosion. The rope had lost 61 percent of the critical strength.

Figure 10

corrosion and the expected concentration of stresses at pit notches and the like. Indeed, the most rapid failures from fatigue have been found to be associated with a peculiar form of wear rather than with corrosion. Under some circumstances of use, the outer surfaces of wires in a rope may become heated locally by severe abrasion to a temperature in excess of 1400° F so that a surface layer of martensite may be formed as the heated metal is subsequently chilled rapidly. Such layers of martensite have been observed to be about 0.002-inch thick. This martensite is hard and brittle and cracks as the rope bends over the drum or sheave. Such surface cracks act as stress concentrating notches and propagate into fatigue cracks which may lead to early failure of the outer wires. This, then, rather than corrosion or simple

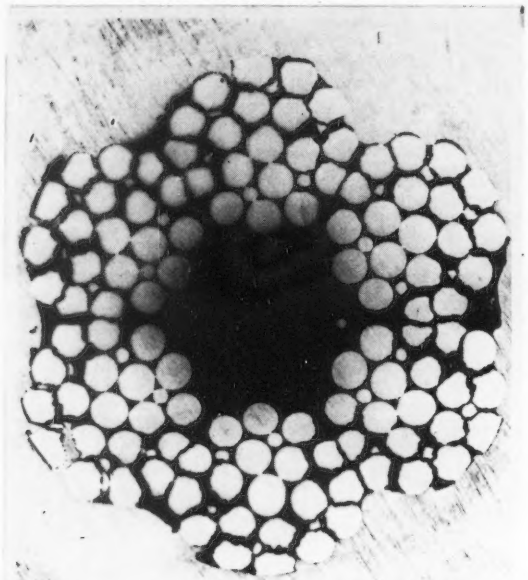
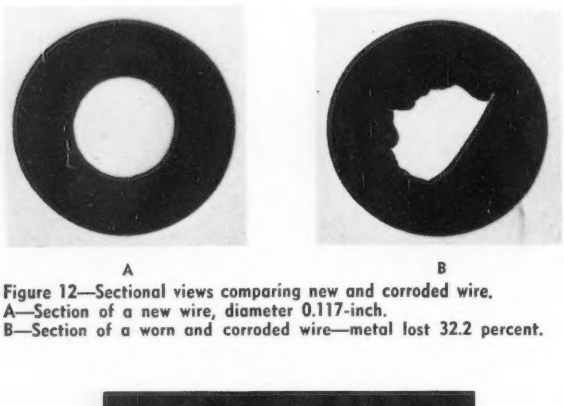


Figure 11—Enlarged view of a section at a point where corrosion had reduced strength by 34 percent.



A B

Figure 12—Sectional views comparing new and corroded wire.
A—Section of a new wire, diameter 0.117-inch.
B—Section of a worn and corroded wire—metal lost 32.2 percent.

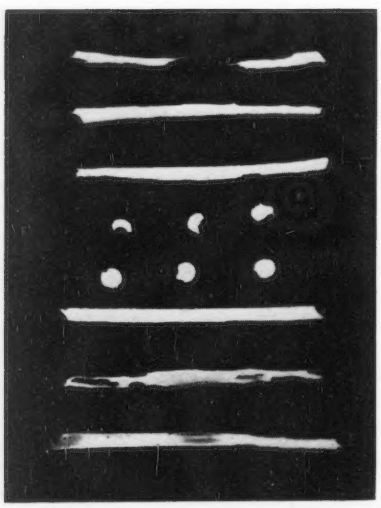


Figure 13—Longitudinal and sectional views of severely worn and corroded wires from a hoisting rope.

fatigue, or corrosion fatigue, is the principal cause of failure of outer wires and is encountered more often on heavily loaded skip ropes than on cage ropes.

Conditions that Favor Corrosion

It is not unexpected that mine water coming into contact with the hoisting rope is the major factor in its deterioration by corrosion, especially when the water is acid and contains such corrosion accelerating chemicals as ferric sulfate and other metal sulfates such as copper and nickel sulfates present in the mines operated by the author's company. The pH of the mine water at the Inco Frood and Creighton mines may be as low as 3.5.

Another expected aggravating factor is moisture in the air passing through the shafts which can condense on the rope. This is likely to be most troublesome when the shafts are used to vent warm moist air from the mine workings.

Protective Measures

The primary means of protection of the wire against corrosion is the lubricant applied when the rope is being manufactured. This lubricant should be of relatively high viscosity and should contain neutralizers and corrosion inhibitors. It should also include an extreme pressure lubricant in order to take care of the very high bearing loads between strands and individual wires.

This internal protection must be renewed and supplemented by dressings applied to the rope during its period of use. The application of these dressings represents a problem which has not yet been solved satisfactorily. Some of the greases that are used must be heated for use and applied to the rope as it passes through a conical grease box at a rate of many feet per minute. It seems likely that the hot grease chills as soon as it hits the cold wire—especially during the winter months in Canada when the heavy wire rope has to travel several hundred feet through the outside air at sub-zero temperatures between the hoisting drum and the collar of the shaft where the grease is applied. It would be surprising if much, if any, of the grease applied in this way ever reached the interior of the rope where corrosion is most likely to occur and where the protective grease is needed most.

The trend seems to be to make the exterior dressings of the same general character as the internal lubricant, but less viscous. It would also seem to be desirable to supplement the fairly viscous dressings applied at intervals with a constant spray, or drips, of light oil applied at the sheave.

Devices for removing old grease and water from the rope as by passing it through a split rubber wiping gland should be helpful as a supplementary preparation of the rope to receive a renewal of its exterior grease dressing.

Corrosion Test Program

As a sort of sighting shot on the possible protective values of a series of oils and greases offered for use in dressing wire ropes, specimens of steel in the form of cold drawn bars or of sections cut from the

outer wires of a new rope were coated with the different compounds and were mounted in racks attached to cages in two of the Inco mines at Copper Cliff, Ontario. Uncoated specimens were included for comparison.

This test ran for about a year with specimens carrying each of the coatings being removed for reweighing and visual examination at the end of each of three time intervals.

Results of this test are shown in Table 1.*

This was admittedly a rough test which it was thought might at least throw some light on the protective characteristics of the compounds even though the circumstances of their use did not approximate the conditions within an operating rope where they would have to function. Nevertheless, it may be significant to note that the two compounds which showed up well in this test have also performed unusually satisfactorily in service as applied to ropes being used to put them to a full scale practical test.

It is planned to repeat the tests with the more promising compounds and to improve the test procedure by:

1. Arranging for periodic renewal of the coatings on the test specimens.
2. Using mechanical tests before and after exposure as supplementary measures of corrosion damage.

It seems desirable to repeat that the greatest improvement in the life of mine hoist cables will have to come from the use of improved lubricants, dressings and better methods of application. It should be evident that there is considerable room for improvement and, while the problem is a difficult one, it should be no more so than others that have been solved satisfactorily by lubrication engineers.

*The author apologizes for the inadequate description of the compounds listed. The data in the table are all that the manufacturers of the compounds saw fit to provide.

References

1. R. E. Dye, *Bull. Canadian Inst. Mining & Metallurgical Eng.*, **41**, No. 431, 158-171 (1948) Mar.

TABLE 1
RESULTS OF TESTS OF DRESSINGS ON STEEL SPECIMENS EXPOSED IN FROOD AND CREIGHTON MINES FOR 8 TO 12 MONTHS.

Coating No. Creighton Test	Type	Weight Loss in mg. per sq. dm. per Day		Remarks
		Creighton	Frood	
23	An experimental internal lubricant highly viscous	3.8	4.3	No Pitting
27	Most fluid of external dressing dries to a hard, lacquer like finish of questionable lubricating properties	5.4	....	Moderate Pitting
11	A highly viscous mineral base, applied during manufacture of rope	5.8	....	No Pitting
17	An experimental fairly viscous external dressing	14.1	4.5	Moderate Pitting
19	A relatively viscous lime soap base external dressing. Melting point 250° F.	15.8	8.8	Severe Pitting
25	A stiff grease of high viscosity for internal lubrication.	16.5	....	Erratic performance
21	Low viscosity external rope dressing	16.8	11.7	Severe Pitting
13	Silicone grease for high temperature lubrication	16.8	8.9	Moderate to severe Pitting
15	Fairly viscous external rope dressing-lime soap base containing lead oleate and pine oil melting point 190° F.	19.1	3.6	Moderate Pitting
29	Unprotected bare steel.....	23.6	18.2	No Pitting
3	Conforms to U. S. Army Ordnance spec. AXS-934 Grade II Engine Oil SAE 30	24.9	19.3	Deep Pitting
7	Medium viscosity dressing..	26.1	....	Severe Pitting
9	Silicone oil with corrosion inhibitor	28.3	22.2	Severe Corrosion
5	High viscosity oil—not a lime grease for external dressing	32.1	17.6	Severe Pitting
1	Conforms to U. S. Army Ordnance Spec. AXS-674 Relatively high viscosity	41.9	20.3	Severe Pitting

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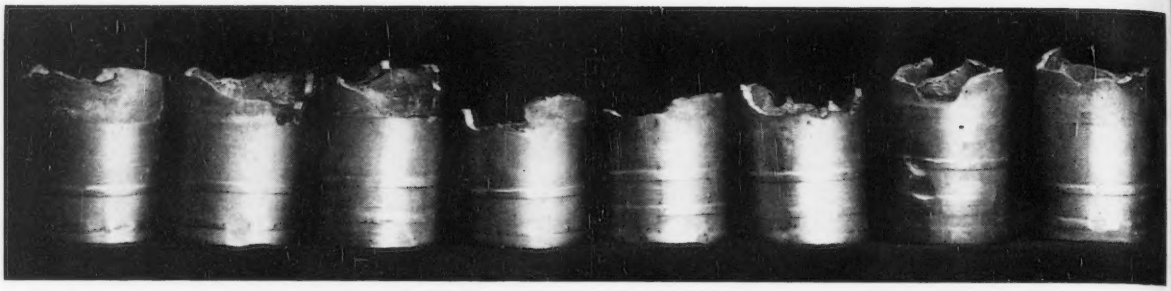


Figure 3—Vibration. Tube ends fractured near tubesheet.

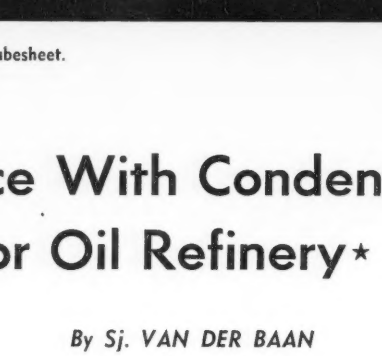
Experience With Condenser Tubes At a Major Oil Refinery*

By Sj. VAN DER BAAN

Introduction

THE ARTICLE of H. E. Bethon[1] on the performance of steam condensers aboard U. S. naval vessels will be welcomed by many as an important contribution to knowledge regarding the selection of the best materials for condensers in marine service.

As condensers are important pieces of equipment also in oil refineries, the writer presents here some of the information which has been collected at the Curacao Refinery of the C.P.I.M. (Royal Dutch-Shell Group). The performance of the tubes of product- and steam-condensers has always been under close supervision and the total number of copper-alloy tubes now in use is well over 300,000.



DR. SJOERD VAN DER BAAN

Corrosion specialist and head of the metallographic laboratory of the C.P.I.M. refinery, Curacao, DWI. He holds a PhD degree from the University of Groningen, Holland. Before the recent war he participated in aviation gasoline research at the Royal-Shell Laboratories, Amsterdam.

Experience here with aluminum brass tubes is more favorable than that recorded in the article mentioned, so it was felt that publication of the Curacao refinery results might lead to a better appreciation of the possibilities of this useful alloy. Product condensers and steam condensers will be dealt with separately, as the conditions for each are radically different. Both types of condensers are served with the same cooling water, which is seawater from Schottegat Bay. This water has a pH of 7.0 (instead of 8.3 for fresh seawater) and a fairly high percentage of very fine suspended matter. The temperature varies between 27 and 32° C, and often some free air is present.

Product Condensers

With the exception of the pressure distillate condensers in the cracking units, nearly all condensers are of the shell and tube type. The temperature of the incoming vapors may range from 80 to 330° C. All tubes are of inhibited aluminum brass which has proved itself through a number of years to be the most economical choice for local conditions and superior to admiralty, cupro-nickel or aluminum bronze.

The standard wall thickness of tubes (5/8") is 19 B.W.G., with 16 B.W.G. for severe conditions. It is very seldom that a leak occurs in a new bundle within two years, while the service life of a bundle is six to eight years, before retubing is necessary; leaks developing meanwhile being dealt with by plugging off the tubes up to a total of about 15 percent. In nearly all cases where premature failure has occurred it has been possible to trace the cause with, however, one important exception, and that is the quality of the aluminum brass itself. The aluminum brasses of various manufacturers (British, American, and before the war also German and Czecho-Slovakian) can be divided as regards corrosion resistance into two distinct classes, one with very low corrosion penetration rates and the other with corrosion rates of 2 to 4 times greater. There is ample statistical evi-

★ Submitted for publication January 7, 1949.

dence for this statement, but as yet it has not been possible to correlate this difference in corrosion resistance with differences in composition, hardness, grain size or surface layer.

At the product side the corrosion product is a thin, black, dense scale which consists mainly of copper sulphide. In some cases this scale has been formed by sulphur compounds (mostly H_2S) in aqueous solution (as in gasoline condensers); in other cases (as in cracked gas oil condensers) no water has been present as a separate phase. This led to the belief that resistance against sulphur compounds, especially H_2S, was a major requirement for our condenser tubes and a very great number of tests have been made in which various copper-alloys have been tested inside a high pressure fractionating column of a Dubbs cracking unit. Here the test specimens are exposed to the action of liquids and gases with S-content of 0.2 to 3 percent, at temperatures ranging from 250 to 370° C. These tests have been in progress for about five years and a very good correlation between corrosion rates thus found and plant experience has been established. For example compared with gasoline condenser service, the corrosion rates are consistently 4 to 6 times higher, which is of course very useful for accelerated testing.

An interesting outcome of these tests is the fact that tubes with 74 Cu 2 Al and 24 Zn were decidedly superior to those of the same manufacturer, with 76 Cu 2 Al and 22 Zn, which is in agreement with the well known superior resistance of high zinc brasses against high temperature sulphur corrosion but somewhat contrary to current specifications, where mostly copper 76.0 percent min. is specified (ASTM B-111).

It seems also to be advantageous that the last operating manipulation be annealing in a slightly oxidizing atmosphere, forming a very thin oxide skin and giving the tube a hardness of 90-100 Brinell. This seems to be better than a final pickle with a straightening pass on the rolls but information on this important point is meagre as in most cases the exact method of finishing is not known.

With "good quality" aluminum brass, failures seldom occur but with "low quality" they are frequent. Below are given a few case histories for the former that may be of more general interest because with "good quality" material it always has proved possible to find simple remedies against various types of unexpected corrosion.

Corrosion by Acidic Condensate

This is the most general form of corrosion of product condensers and in the majority of cases the reason of ultimate failure. The acids concerned are HCl, H_2S, various organic acids, CO_2 and sulphur compounds such as mercaptans which can form metal salts.

Fortunately, serious corrosion will only occur if water is also present in the liquid phase and then proper neutralization will restrict it within acceptable limits. At Curacao this is accomplished by the injection of caustic soda solution upstream of the condensers; the pH of the condensed water being thus kept between the limits of 5 and 8. Ammonia injection has proved to be equally effective elsewhere. Aluminum brass is not sensitive to an occasional overdosage of diluted caustic soda; indeed a cooler-bundle for hot regenerated strong doctor solution (alkaline sodium plumbite) lasts about three years. This soda injection is only practiced at the topping units; it has been found to be not necessary for the condensers of the cracking plants, although the sulphur and organic acid content of the cracked vapors is far higher. (This anomaly is probably due to the presence of natural inhibitors in the fresh pressure distillate. After the pressure distillate has been in contact with air for some time it becomes corrosive and must be neutralized.)

Impingement Attack

This has been notably only by its complete absence. Even when air was admitted to the suction side of the large centrifugal salt water pumps in order to minimize cavitation damage in these pumps, no adverse effects on the tube ends were noted, although these were closely watched during this period. Finally the admission of air had to be stopped because of serious impingement attack on the Naval brass tube sheets of some condensers which were situated near the pumps. The tubes, however, did not show any sign of attack. Tube-end protectors are not used anywhere.

Dezincification

Failures due to plug-type dezincification, starting from the cooling water side, have not occurred during the last eight years at this refinery, but that this kind of failure is not a thing of the past, is shown by Figure 1, which illustrates a tube which was received a year ago from a gasoline condenser of a Venezuelan refinery after a few months' use.

Chemical analysis revealed the absence of inhibiting elements such as As, Sb or P. In this connection

Figure 1—Dezincification. Porous red copper plugs and holes in flattened piece of tube. (X3)

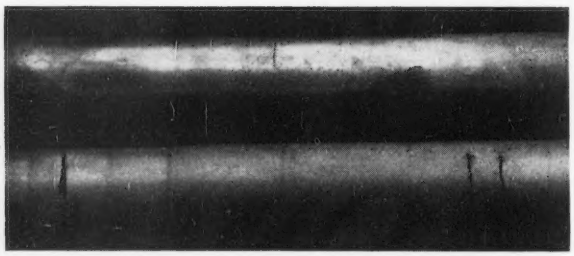


Figure 2—Stress corrosion cracking caused by HCl.

it is noteworthy that ASTM Spec. B.111-46 specifies a maximum of 0.1 percent arsenic, antimony or phosphorus for aluminum brass type B, C and D respectively, but does not specify any minima which are required for complete protection against dezincification.

Stress Corrosion Cracking

In butane isomerization units at Curacao refinery a gaseous mixture of normal and iso-butane with anhydrous HCl is led through condensers before entering the HCl stripper. After satisfactory behavior for about two years the Admiralty tubes of these condensers had to be renewed and were replaced by aluminum brass ones. At the same time a second unit, also provided with aluminum brass tubes, was brought into service. In both cases a large number of tubes showed transverse cracks within about three months (see Figure 2). The bundles were retubed, but showed the same kind of failure again within a few months. Soft, completely recrystallized material of American origin (Brinell hardness 65-70) showed the same sort of cracks as hard English material with a Brinell hardness of 142-163. The cracks were of an intercrystalline nature, and were spread irregularly over the whole tube length, sometimes starting from scall notches at the tube surface, such as indentations caused accidentally by hoisting cables. This could point to corrosion fatigue and in fact it was found that sometimes a noise like water boiling could be heard in the water channels of these condensers.

When the second unit was put into service the water supply system was not enlarged and therefore use was made of the siphoning effect of the descending outlet tubes to secure an adequate flow of cooling water through the condensers. The resultant partial vacuum caused boiling of the water, which may have resulted in vibration of the condenser tubes.

It was found subsequently that a combination of the following measures gave good results. The tubes were annealed full length for one hour at 500° C, then they were expanded into the tube sheets without removing the fairly thick black oxide scale and also a vent pipe was installed in the outlet of the water boxes to break the vacuum. With these measures tubes of that batch which formerly cracked within three months have now given well over 18 months service without a single crack occurring. There are indications that the annealing was essential for this improvement and that the vacuum breaker played only a minor, if any role.

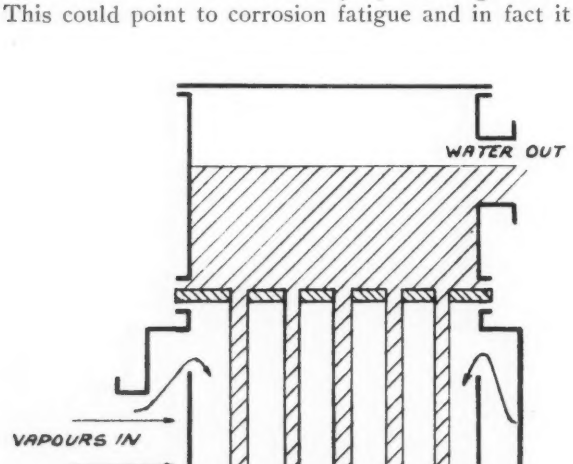


Figure 4—Vertical condenser showing efficient baffling of incoming vapors.

Fatigue and Corrosion Fatigue

When aluminum brass tubes are allowed to vibrate, the results often will be brittle fractures just behind the tube sheet, as pictured in Figure 3. This failure occurs more often in cooling elements with header boxes than in shell and tube condensers, because in the first mentioned form the unsupported tube length is usually considerably greater. Fractures will occur sooner when:

a) the tube material has a high hardness,
b) the hardness in the expanded portion of the tube has been increased too much by the rolling operation,
c) when the tube is rolled in too far behind the tube sheet,
d) the vibration is of greater amplitude.

This phenomenon has been found in systems with oil vapors outside, cooling water inside (reflux condenser inside vacuum tower) and in submerged condensing elements with the oil vapors inside. When it is impossible to stop the vibration it is often possible to reduce the amplitude sufficiently, by the insertion of more and/or closer fitting baffles, to effect a complete cure provided proper care has been taken of the points mentioned above under a, b and c.

In one case the trouble was completely stopped by the insertion of three baffles instead of one, and in another case wooden staves were driven between the rows of tubes to a tight fit, also with complete success.

The cause of the vibration in shell and tube bundles is mostly impingement by vapors with a high velocity in a direction normal to the tubes and installation of a series of perforated distribution and deflection plates will frequently be found to be successful as a preventive measure. Vertical condensers with a vapor inlet as shown in Figure 4 are considerably better than the usual horizontal condenser where the vapors impinge directly on the tubes.

Sometimes vibration is set up by water boiling

under reduced pressure somewhere in the tubes and the steam bubbles imploding against the tube wall further on. In this case increasing the water pressure and/or the installation of a vacuum breaker at the cooling water outlet will stop vibration.

High Temperature Attack, Hot Spots

Ordinarily speaking, aluminum brass tubes are resistant against very hot vapors, provided there is an uninterrupted flow of cooling water through the tubes. When the flow through the tubes is restricted and the water starts to boil, rapid local perforation of the tube wall may result. If the steam bubbles are formed continuously at the same spot, it often happens that the attack is concentrated at this point. The combination of higher salt concentration at the tube surface, and higher wall temperature (because the cooling at the place of formation of the steam bubble is inadequate) seems to be particularly dangerous. Hot vapors impinging at high velocities against a tube wall can cause perforations in amazingly short time. Figure 5 shows a picture of a tube from a cracked-gas-oil condenser, wall thickness 14 B.W.G. The temperature of the entering vapors was 330° C. The cooling water supply failed suddenly due to a defect in the electrical circuit) and the unit was shut down. About 30 minutes elapsed before gas formation ceased and in that time the hole had been formed. There is no appreciable thinning of the tube wall near the hole; some hard salt scale is present inside the tube.

A tube of another condenser, which failed on the same occasion is shown in Figure 6. This form of corrosion, however, occurs very seldom and it can easily be circumvented, if working conditions make this necessary, by lowering the temperature of the entering vapors by quenching upstream with part of the condensate.

Steam Condensers

Land Installations

Because obtaining sufficient boiler feed water is a problem in itself on a dry island such as Curacao, steam condensation is practiced wherever possible. The large steam-using units are the turbines of the powerhouses (up to 12.500 kW) but also the exhaust steam from both turbine-driven centrifugal pumps and reciprocating pumps is condensed whenever possible, the total amount of condensate beign about 400 tons/hour.

The main difference between the product- and steam-condensers is that in the product condensers the tubes are expanded at both ends with a floating head arrangement and in the steam condensers ferrules are used at least in one and sometimes in both tube sheets.

Admiralty tubes have not given satisfactory service, the failure always being pitting, starting from the cooling water side. Cupro-nickel (70-30) was decidedly superior, but not better than aluminum brass which is about 30 percent less expensive.

Both kinds of material were, however, subject to sudden epidemics of leaky tubes which occurred at irregular intervals. After a few years it was noticed that these occurrences coincided with dredging operations near the inlet channel of the salt water pumphouse and it became clear that the trouble was due to deposit attack, see Figure 7. Now, dredging is stopped as soon as the water reaches a certain turbidity and leaks due to this cause are practically eliminated. It may be noted that in vertical condensers this form of corrosion is practically unknown. Generally speaking, the tubes of steam condensers give very little cause for complaint.

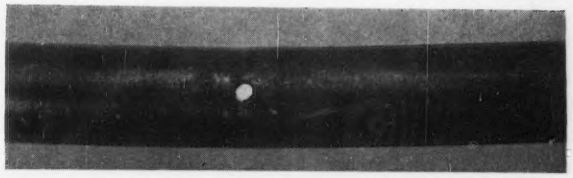


Figure 5—Hot Spot. Perforation in thick tube wall when exposed for 30 minutes to hot, high-velocity vapor.

Figure 6—Hot Spots. Holes similar to those in Figure 5 formed on the same occasion in another tube bundle.

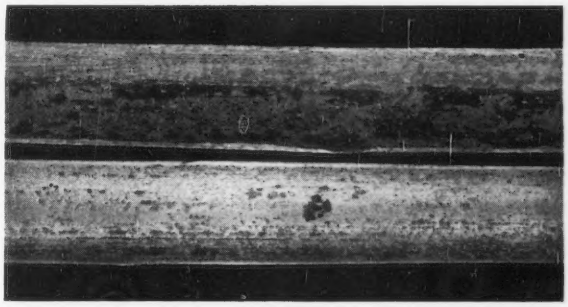


Figure 7—Deposit attack. Lower half of tube cleaned, showing many small pits and a hole. In upper half silt scale still partly present.

Marine Installations

Crude oil is shipped from Venezuela to this refinery in a fleet of shallow draft tankers, ranging from 2400-6000 tons. These double screw ships are equipped with compound steam engines and for condenser tubes invariably aluminum brass is used. This gives very satisfactory service, even though the cooling water is alternately sea water from the Caribbean and comparatively fresh water from the Lake of Maracaibo. Condenser tubes have a useful life of about 12 years. The only mishap occurred when admiralty ferrules were used with aluminum brass tubes; the admiralty brass corroded in a short time.

Other Condenser Parts

Tube sheets and baffle plates are generally made of naval brass, which is in most cases satisfactory. When cast iron water boxes were replaced by bronze

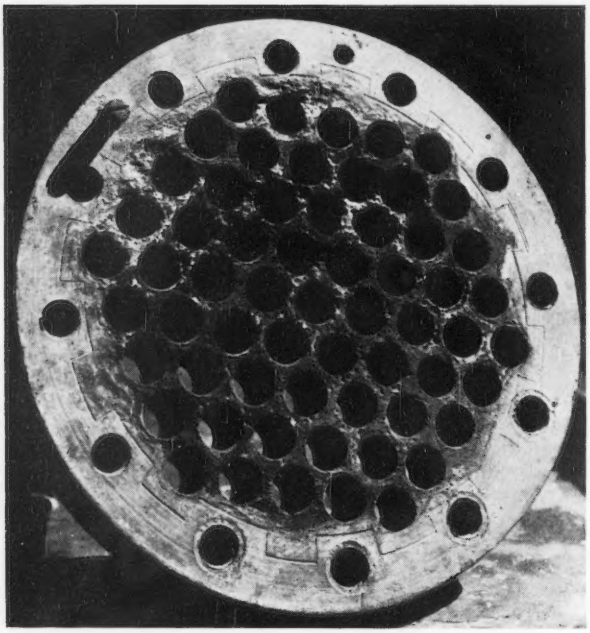


Figure 8—Galvanic action. Rapid corrosion of naval brass tube sheet under influence of bronze (88-10-2) water box.

ones serious dezincification of a number of tube sheets resulted. (See Figure 8.) The use of sacrificial steel slabs inside the water boxes helped to overcome this difficulty, but preferably a cast brass (selected so as to be galvanically neutral to the rolled naval brass sheets) should be used. At the moment manganese brass is being tested, in combination with steel plates, to stop any tendency to dezincification.

Bronze header boxes in submerged-type condensers failed because of insufficient resistance to hot cracked vapors with an appreciable sulfur content.

In very large condensers cast iron water boxes may prove to be more economical than copper alloy ones. They must be well protected with zinc slabs which should be freed from the white impervious coating of corrosion product every 3-6 months, while a good metal contact is essential. Frequent painting of the inside cast iron surface with an insulating paint (asphalt or coal-tar base) also has shown favorable results even if the paint is eroded a little by high velocity flow of the cooling water.

Conclusions

1. Aluminum brass of good quality is a versatile and economical condenser tube material for the conditions prevailing at Curacao.
2. Compliance with the usual specifications is not in itself a guarantee of adequate performance, as corrosion resistance depends on other factors also which as yet are not known with certainty. Full length annealing to a hardness of ±100 Brinell and the formation of an oxide skin are probably beneficial in this respect. On this topic, however, more research is certainly needed.
3. A reasonably cheap and satisfactory alloy for water boxes to be used in connection with naval brass tube sheets is still sought for.

References

1. Bethon, H. E., *Corrosion*, **4**, 457-462 (1948) Oct.

DISCUSSIONS ARE INVITED

Readers who wish to submit written information additive to articles published in CORROSION, or who wish to register differences of opinion with respect to any articles are urged to send such discussions to Dr. F. N. Alquist, Chairman, NACE Editorial Review Committee, Organic Research Laboratories, 20A Building, Dow Chemical Co., Midland, Mich. Doctor Alquist will submit such discussions to a member of the review committee, and after review and approval the discussion will be published.

The expression of opinions about or the addition of information to that contained in technical articles will advance the interests of NACE and make CORROSION more valuable to the membership.

Preparation of Pipe Surface For Bitumen Coating During Reconditioning*

By O. C. MUDD*

Abstract

The exterior cleaning of pipe after removal from soil in the preparation for bitumen coating application is a major item of expense during reconditioning. Removal of all adhering material from the metal surface can be accomplished most practically by sandblasting or equivalent treatment. However such procedure is expensive and slow, especially when the line remains intact or in service. Most corrosion products and soil particles are inert in the absence of moisture and the retention of small amounts of such materials on the pipe surface, particularly when adherence is good, will not impair coating effectiveness if moisture is removed. Moisture can be removed by chemical treatment at a reasonable cost, thus reducing cleaning costs without impairing coating results. A solution of diluted pipe primer has been found effective in reducing moisture content of the residual foreign products on the pipe surface.

A GOOD COATING for protection against underground corrosion will be obtained on pipe only if it is properly cleaned before the coating is applied. To do such cleaning economically presents a problem to the pipe line operator and his engineer. This is particularly true when hot bitumen is to be applied to coat or recoat steel pipe salvaged for relaying in new lines, or in operating lines raised from the ground for reconditioning.

Some engineers believe that removal of corrosion products down to the base metal—usually a very expensive process—is the only practice that will insure a good coating. The writer challenges this belief and describes less expensive alternative cleaning and coating application practices evolved after experiences with sand blasting and other practical cleaning methods that have given equally good results.

Pipe taken out of the ground is often covered by tightly-adhering silicious materials that resist removal by ordinary cleaning; also, most hot-applied bitumen pipe enamels contain silicious materials as a filler. Why not leave in place those non-metallic substances that resist removal by ordinary cleaning, but chemically drive out the moisture and saturate the surface with appropriate inhibitors or priming solutions?

Chemical treatment of machine-cleaned metal surfaces has lead to changes in methods for cleaning the exterior of used pipe to give better economy and obtain improved coating results.

Brief consideration will be given first to conventional methods of cleaning pipe after removal from the ground, to the equipment used and the problems encountered.

Cleaning Methods and Equipment

The three common cleaning methods are:

1. Mechanical cleaning
2. Sand or "grit" blasting
3. Flame cleaning

1. Mechanical or rotary cleaning machines built to travel along pipe lines are perhaps best known in the industry. Usually all pipe removed from the soil is given at least one "pass" through such machines before additional cleaning by the same or other methods. Such machines usually can be adapted also to stationary operation. Their rotary cleaning-heads customarily are equipped with knives, cutter-wheels or brushes or combinations of these abrasive tools.

Some of the newer and larger machines have double cleaning heads. These should rotate in opposite directions to obtain better cleaning of corrosion pits, welds, and patches or other longitudinal irregularities. Also, opposite rotation machines ride the line better. Severely corroded pipe requires repeated "passes" of such machines to prepare a surface suitable for normal primer application.

Mechanical cleaning-machines of the "impact" type have been developed to hammer or "peck" the surface and dislodge foreign material, thus approaching the results of sand-blasting. They give excellent results, but the wear of added mechanical parts makes their operation expensive. One "pass" of such machines will usually prepare a pipe surface for primer application; however, if a rotary-head machine is run first, it will minimize wear of parts on the more complicated impact machines.

2. Sand-blasting and "grit" blasting are equivalent to the extent that both dislodge foreign materials by impact or cutting action of extraneous particles.

Sand-blasting is normally done by accelerating sand particles in an air stream and directing them through a nozzle against the surface to be cleaned. The angle of particle impingement affects the rate of cleaning and surface finish. The type of sand—particle form and size—influences results. Best results are obtained with "sharp" sand, viz; particles with sharp edges. Most sand which has been washed or wind blown for some time has lost these sharp edges and does not have good cutting qualities.

A single sand-blasting unit with ½-inch nozzle

★ A paper delivered at the Fifth Annual Conference, National Association of Corrosion Engineers, Cincinnati, Ohio, April 11-14, 1949.

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requires 340 cubic feet of air per minute at 60 to 80 psi, one or more sand-chambers with control-valves and hose of proper design for this operation. Sand must be dried thoroughly for sand-blasting, thus it is preferable to have the drier apparatus where the sand is being used. Slight moisture in sand clogs control-valves, piping and hose—thus causing irregularity of sand flow. Sand delivery from a ½-inch nozzle is around 3,000 pounds per hour, thus supply becomes a major item and may even be prohibitive because of transportation costs to some locations.

"Grit" blasting uses hard steel particles about the size of bird-shot. An average machine for yard operation will contain a few tons of steel grit which recycles. The grit is raised to an overhead hopper, whence it gravitates into a rotating impeller designed so as to discharge it at a high velocity in a continuous stream equivalent to that from a large sand-blast nozzle. After impingement on the pipe surface, this grit drops to a recovery bin where foreign material is removed by air blast after which the grit is returned to the hopper. Grit loss is only a small item with such equipment. Power demand for the average "grit" blasting unit is around 75 kw. A portable power-plant is required if power service is not available. Although "grit" blasting has been limited to stationary operations, some progress has been made in the design of a traveling type for field use.

3. Flame-cleaning has been used occasionally. It is effective for moisture removal, but it has disadvantages of high operating cost, hazards around inflammable materials, and localized stressing of metal. Such local stressing may permanently warp thinner pipe or damage welds under stress.

High-frequency electric induction-heating devices, with the frequency controlled to give proper depth of metal heating, may have possibilities.

Cleaning methods on any job will be determined by the degree of cleaning necessary and by their cost and practicability.

Some Initial Pipe-Cleaning Problems

Lines in Service

Pipe raised from a trench is covered more or less with earth in large quantities if removed from clay soils, or with little or none if from clean sand.

A single pass of a traveling-type cleaning-machine equipped with knives only, or with knives and cutter wheels, will usually clean uncoated pipe enough to allow inspection for repairs.

If the line has been coated, other cleaning procedures are required. Coal-tar enamel coatings, with or without wrapper, usually can be removed by a single pass of a traveling-type machine equipped with knives only, especially in cold weather.

Well-bonded asphalt enamel coatings are more difficult to remove than coal tar, although a machine equipped with knives only has given better results. In summer the cleaning is easiest done during the cooler hours of early morning or at night. Wetting the coating ahead of the machine helps to cool it, but such practice may accelerate knife wear.

Asphalt-emulsion coatings are more difficult to remove than asphalt enamels, and their complete removal may require more than one pass of a cleaning-machine equipped with knives. The use of water during mechanical cleaning has given favorable results at times.

Removal of petrolatum or grease-base coatings requires more than mechanical cleaning. The first operation is best accomplished by a traveling machine with knives only. A second pass with the same machine may be needed. Cleaning afterwards is done by successive washings of the pipe with rags soaked in kerosene or distillate. The pipe is cleaned sufficiently when dust does not adhere, or where a spot of applied primer does not show a "dead" surface when dry.

Yard Cleaning

Pipe racked up for yard reconditioning is more susceptible to atmospheric temperature changes than pipe in which gas or oil is flowing. Cooler weather facilitates removal of some pipe coatings that may be difficult to remove during hot weather.

The initial cleaning of bare or coated pipe for inspection and repair is most usually done with a stationary mechanical machine equipped with knives. Standard coal-tar enamels respond to such cleaning without serious difficulties. Plasticized coal tar, asphalt enamels and some types of asphalt emulsions can be removed satisfactorily by rotary-head machines only during cool weather. The upper temperature limit for satisfactory removal is evidenced by clogging of the cutter knives. A stream of water directed on the pipe before entering the machine will often help cleaning during warmer weather.

Additional cleaning with a conventional type machine is required after repairs or grit-blasting may be justified for final cleaning in some cases before priming.

Some coating, particularly asphalt emulsions and grease-base paints, are removed most successfully by burning. This operation is better done by applying heat from inside the pipe. The pipe should be well supported when the burning operation is in progress.

The types of burners suitable for this operation depend on 1) whether there is combustible residue in the pipe and 2) the type of exterior coating. Natural or liquefied gas gives better results for such burners, and plenty of compressed air is needed for combustion control. Air supply to the burner determines the length of combustion zone in the pipe, and it also controls the "ram jet" effect. The combustion zone should be as long as possible to prevent localized heating and give lowest fuel consumption.

When coating is burned from pipe, the surface should be heated enough to carbonize any remaining film, providing such temperature does not damage the pipe. Rotary machines, equipped with a combination of knives and brushes, will remove carbonized paint leaving the surface ready for primer application.

Supplementary Chemical Treatment for Additional Cleaning

Any possible elimination of any mechanical clean-

ing without impairing final results will reduce cleaning expense. Some reduction in cleaning can be compensated for by chemical treatment as mentioned earlier.

Development of chemical treating during several years of pipe reconditioning has shown the advantage of its substitution for additional mechanical cleaning.

First experiments were prompted when sand-blasting of pipe failed to provide a satisfactory bond for asphalt enamel. Dilute primer* was applied to freshly sand-blasted pipe to prevent moisture collection and oxidation. Regular consistency primer was applied after the dilute primer had dried. The hot asphalt enamel coating then bonded better. A similar primer application was then tried over extensive lengths of machine-cleaned pipe. The bond of the hot asphalt improved, besides which fewer holidays occurred because the dilute primer had removed the moisture from tightly-adhering corrosion products, including such as remained in small deep pits.

Use of the same procedure for bonding hot coal-tar enamel to machine-cleaned pipe gave equally satisfactory results.

On one reconditioning job in the East Texas humus-covered "big thicket," the moisture and chemicals left in small deep pits after machine-cleaning actually brought the coating application to a halt. Pipe subjected to three passes of a cleaning machine was washed with water and allowed to dry in the sun. Then it was covered with dilute primer. After the latter dried a few minutes, its surface appeared to be covered with frost. Microscopic examination showed that chemically-laden water had been forced to the surface, where it evaporated and left the included chemicals as crystals. These crystals fell from the pipe on further drying.

Dilute primer probably does not remove all moisture from the remaining corrosion products, but it reduces the amount to such a degree it causes practically no trouble with hot bitumen applications. Also, chemicals are available which will insure removal of *all* moisture. These are discussed later.

Combining Mechanical Cleaning and Chemical Treatment

Best results usually are obtained with three passes of rotary-head machines. The first pass serves to clean the pipe for inspection and necessary repairs. Choice of cleaning elements for this machine will depend on what has to be removed from the pipe. Corrosion on pipe usually occurs in short section over which the machine should travel at slower speeds than on lesser corroded sections.

The machine for the second pass is normally equipped half with knives and half with brushes, and with a priming attachment added. This machine removes additional corrosion products and welding residue, and it applies the dilute primer.

To obtain saturation of remaining corrosion products in any pits or depressions, complete coverage of the pipe surface by the dilute primer is essential for good results. A satisfactory solution can be made by adding four parts primer thinner to one part primer, although conditions may call for changes of this ratio.

The solution after drying will have a dull appearance, and may even appear "chocolate brown." Where considerable corrosion products remain in pits, the primer will appear duller than over adjacent surfaces. Where all tightly-adhering products are saturated, the dried dilute primer presents a surface to which the normal-consistency primer readily fuses or adheres, thus giving excellent final bond between pipe and the hot bitumen enamel.

The drying time for the dilute primer should be not less than three hours during sunshine nor less than half a day when the sky is overcast.

The machine for the third pass should be equipped with knives only, preferably a single-head type, and carry a priming attachment for application of normal consistency primer. This machine removes some additional corrosion products which have been loosened by the dehydrating action of the dilute primer.

Improvements in Chemical Dehydration

As mentioned before, the dilute primer does not remove all moisture, but chemicals can be added to it that will remove and exclude all moisture from the metal surfaces. These are mostly amines, such as used in rust-inhibiting oils and greases. The addition of corrosion inhibitors may be desirable also. Tests under actual service conditions will answer the question as to their value.

Conclusions

Cleaning pipe surfaces during reconditioning is costly; therefore the available methods of cleaning should be analyzed as to effectiveness and cost before starting a job. Use of dilute primer reduces the amount of mechanical cleaning necessary, and it materially improves the coating bond. Water-repellent and corrosion-inhibiting chemicals added to the dilute solution will improve its dehydration properties, but such can be justified only if the advantage is worth the cost.

DISCUSSION

Comment by J. M. Holloway, Houston Pipe Line Co., Edna, Texas:

Since Mr. Mudd has mentioned in his paper the internal heating of pipe in the preparation of pipe surfaces during reconditioning, the experience of another company might be of interest.

In the cleaning process the internal heating of badly corroded pipe accomplishes two objectives. It frees the pipe of all coatings, such as coal tar enamels, asphalt coatings and greases, and it calcines the hard rust to a powdery state in which condition it can be more easily removed from the pipe and out of the deep pits. In sandblasting the rate of cleaning is increased by several hundred percent and all

* Dilute primer referred to in this article is prepared by the addition of primer thinner to the primer supplied or recommended by the bitumen enamel manufacturer.

the products of corrosion can be cleaned out of the pits leaving a clean bright surface for spot welding pit holes. With a mechanical cleaner a much better job of cleaning can be done than with no heating, with only a small percentage of the corrosion products remaining in the pits.

It was found that pipe smaller than 8-inch diameter could not be successfully heated by applying the flame inside. However, on larger pipe the process was very successful. The burner consisted of a short piece of ¾-inch pipe, centered by a spacer ring, with four gas jets made from ⅛-inch pipe and placed so as to give a long whirling flame. A 20-foot joint of 16-inch pipe could be heated sufficiently, just below incipient red heat, in from 5 to 8 minutes and required approximately 600 to 1,000 cubic feet natural gas, depending on ambient temperature.

Author's Reply:

Comments by Mr. Holloway regarding pipe cleaning by internal heating are most interesting and particularly of value in that fuel consumption, time of heating, pipe size and results are given.

Contributions of this kind are needed to assist others confronted with similar problems.

Corrosion of Wet Steel By Hydrogen Sulfide-Air Mixtures*

By D. C. BOND and G. A. MARSH

Introduction

INFORMATION was desired concerning the initial rate of corrosion and the nature of the corrosion products formed by the action of H_2S-air mixtures on wet steel. This information should be applicable to a fundamental study of the corrosion occurring in the vapor space of tanks used for storing sour crude oil. It should also be useful in the study of corrosion in the vicinity of wells producing gas containing very high concentrations of H_2S.

A review of the literature indicates that relatively little work has been done on corrosion of steel by H_2S-air mixtures. Milbourne and Huff[1] and Pearson and Robinson[2] studied the influence of humidity on the reaction of H_2S with iron oxide. A related study was made by Hopton and Griffith[3] who were interested in removal of H_2S from fuel gases by means of reaction with iron oxide.

Geld and Essin[4] who studied the mechanism of the sulfide corrosion of iron, found that the composition of components in the lattice structure of the Fe-S system varies over a larger range than in the Fe-O system.

Ballabio and Pastonesi[5] studied the action of H_2S on steels but with special emphasis on alloy composition required to minimize corrosion.

Devine, Wilhelm, and Schmidt[6] investigated the corrosion of steel in H_2S-air atmospheres. Their experiments were carried out using dry steel in gaseous mixtures saturated with water vapor. They found that oxygen is necessary to cause severe corrosion, and that gases low in H_2S are relatively more corrosive than those rich in H_2S. However, their work did not cover the corrosion of wet steel.

It was the purpose of this investigation to extend the study to the corrosion of wet steel, and to include an analysis of the corrosion products.

Apparatus

In all of the experiments carried out for this report, mild steel strips were used, ⅛ x ½ x 1¾ inches. The reaction vessel was a 500 cc 3-neck flask, containing 250 cc of distilled water. The center neck was fitted with a stopper containing a glass sleeve which acted as a bearing for a glass rod extending downward into the flask. A hook at the lower end of the glass rod supported the steel strip. In addition to the sleeve, the center stopper also was fitted with a short length of 8 mm glass tubing which served as an exit vent for the corrosive gas. One of the side necks of the 3-neck flask carried a separatory funnel; the other side neck carried a glass tube extending down into the water inside the flask, for the purpose of admitting the corrosive gas.

A convenient method for keeping the surface of the test strip wet consisted of an alternate immersion apparatus. A mechanical coupling was made from the central shaft to a reciprocating lever which in turn was operated by an electromagnet. The electromagnet was energized for one second each 2½ minutes, by means of a timing relay. Each time the electromagnet was energized, the shaft was lowered two inches, thus permitting the steel strip to be submerged momentarily. The 3-neck flask was immersed in a water bath and held at a constant temperature, ±3° F.

The corrosive gas mixtures used in the experiments were prepared by charging an evacuated 5-gallon bottle with air and H_2S under the appropriate pressures. The pressure of gas was indicated on an open-end mercury manometer. The gas in the 5-gallon bottle was bubbled through the water of the reaction

*A paper delivered at the Fifth Annual Conference, National Association of Corrosion Engineers, Cincinnati, Ohio, April 11-14, 1949.

flask at a rate controlled by a pinch valve on Tygon tubing. The rate was measured on a capillary flowmeter. Nitrogen, also used in some experiments, was obtained from a commercial cylinder and was further purified by bubbling through alkaline pyrogallol.

The entire apparatus is illustrated in Figure 1.

Corrosion Rate of Wet Steel in H_2S-Air Mixtures

A steel test strip was polished on an electric buffer, then further polished with steel wool and fine emery cloth. Then it was washed in distilled water followed by acetone, dried, and weighed.

At the beginning of a run, the 5-gallon bottle was filled with gas of the desired composition by adding air and H_2S according to the pressure required by the mixture. Distilled water was added to the reaction flask after thorough cleaning, and the steel test strip was attached to the sliding central shaft which normally supported it just above the water surface. Suitable adjustments on the lever and electromagnet served to align the shaft to permit the reciprocating motion needed to immerse alternately the steel test strip.

The flow rate of the corrosive gas was adjusted to five liters per hour. The gas, in bubbling through the water, became substantially saturated with water vapor, and, in passing over the steel test strip, presented a fresh corrosive medium at all times.

At the end of a run of two hours duration, the steel test strip was removed from the reaction flask, pickled in inhibited sulfuric acid, and washed, dried, and weighed. Data and results are given in Table I and Figures 2 and 3. Several experiments were carried out at 120° F. using 1% H_2S air mixture, in an effort to determine the rate of corrosion as a function of time over the first few hours of exposure. Data and results are given in Table II and Figure 4.

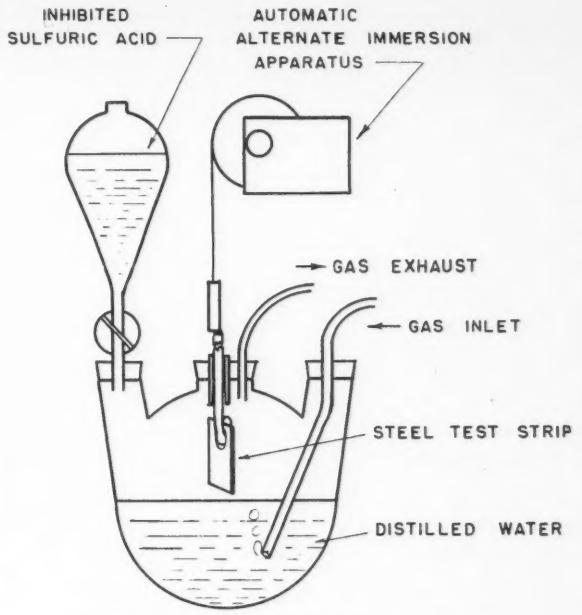

Figure 1—Apparatus used in corrosion tests.

Corrosion Product Composition as a Function of Corrosive Gas Composition

These experiments were carried out at 120° F., using essentially the procedure outlined above. After the corrosion had been allowed to proceed for two hours, the flask was swept out with purified nitrogen until the amount of H_2S present was negligible. At this time the steel test strip was lowered into the water, and the flask was sealed except for an outlet vent. Inhibited sulfuric acid was then added to the water inside the reaction flask by means of the separatory funnel. Any acid-soluble sulfide in the corrosion product was converted to H_2S which was then swept out by a strong stream of purified nitrogen, bubbled through sodium hydroxide solution, and titrated potentiometrically using lead nitrate. The amount of iron present as the sulfide was obtained in this way. The water-acid mixture inside the flask was then shaken with carbon disulfide, which extracted any free sulfur and organic inhibitor present. The CS_2 extract was then evaporated to dryness; residue was then extracted with acetone to remove organic inhibitor. The remainder was weighed after drying and called "free sulfur." The steel test strip was removed from the acid-water mixture, rinsed in dis-

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G. A. MARSH

Corrosion Research Chemist, Research and Development Dept., The Pure Oil Co. He holds a B.S. in Chemistry, Illinois Institute of Technology; M.S. in chemistry, Northwestern University and was research fellow at Corrosion Research Laboratory, I.I.T., 1946-48. He has been employed by the Pure Oil Co. since 1948.

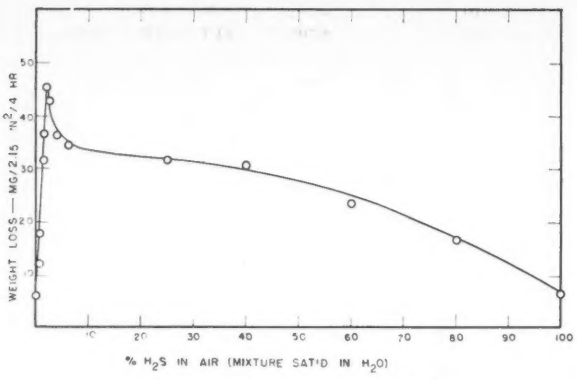

Figure 2—Corrosion rate of wet steel at 70° F.

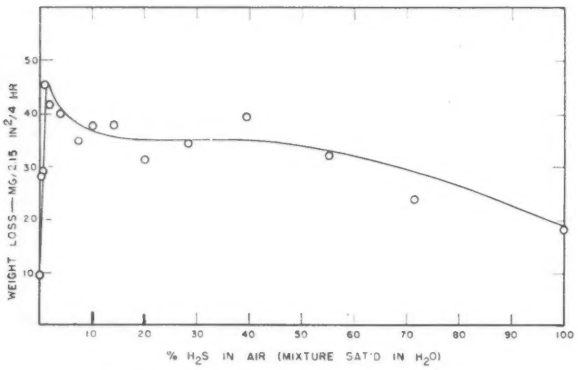

Figure 3—Corrosion rate of wet steel at 120° F.

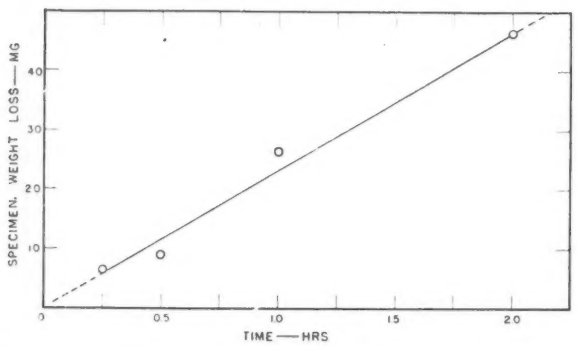

Figure 4—Corrosion of wet steel by moist 1.0% H_2S-Air Mixture, 120° F.

tilled water, dried and weighed to obtain total weight loss of metal over the time interval covered by the experiment.

Such analyses were carried out over a range of H_2S-air mixtures to yield corrosion product composition as a function of corrosive gas composition, as given in Table III and Figures 5 and 5A.

The Oxidation of Wet Ferrous Sulfide

The technique employed in this study consisted of producing a fresh quantity of ferrous sulfide and then allowing this compound to react with air. The same type of steel test strip and alternate immersion apparatus previously described were used. After a certain length of time, the strip was pickled in the closed flask and the liberated H_2S was caught in caustic and titrated. Data collected in this manner

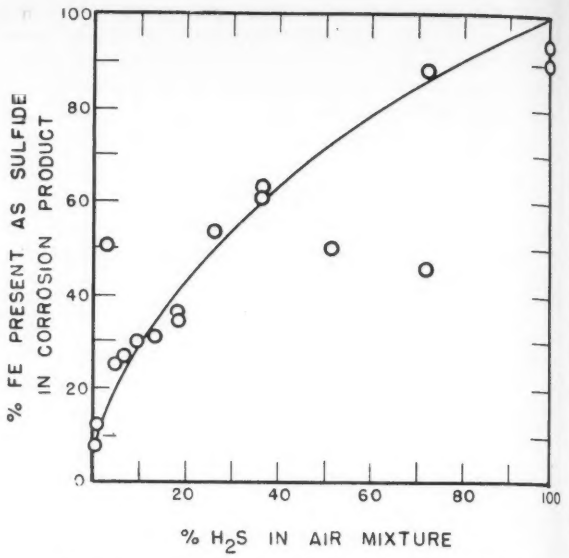

Figure 5—Composition of corrosion product of steel, 120° F.

TABLE I

Corrosion Rate of Wet Steel in H_2S-Air Mixture

A. Temperature 70° F; Water Vapor Approximately 2.7% of Total Gas Volume.

No.	Percent H_2S in Air Mixture	MOLE RATIOS H_2S : O_2 : H_2O	Corrosion Rate Inches per Year
1	0.0	0.0 : 7.7 : 1	0.05
2	0.75	1.0 : 28 : 3.0	0.14
3	0.75	1.0 : 28 : 3.0	0.10
4	1.5	1.0 : 14 : 2.0	0.28
5	1.5	1.0 : 14 : 2.0	0.24
6	2.0	1.0 : 10 : 1.4	0.35
7	2.5	1.0 : 8.2 : 1.1	0.33
8	4.0	1.4 : 7.3 : 1.0	0.28
9	6.3	2.2 : 7.1 : 1.0	0.26
10	12.5	4.5 : 6.6 : 1.0	0.32
11	25	9.0 : 5.7 : 1.0	0.25
12	40	14 : 4.5 : 1.0	0.23
13	60	21 : 3.0 : 1.0	0.19
14	80	29 : 1.5 : 1.0	0.13
15	100	36 : 0 : 1.0	0.05

B. Temperature 120° F; Water Vapor Approximately 12.1% of Total Gas Volume.

16	0.0	0 : 1.5 : 1.0	0.08
17	0.25	1.0 : 84 : 55	0.22
18	0.50	1.0 : 42 : 27	0.22
19	1.0	1.0 : 21 : 14	0.22
20	1.0	1.0 : 21 : 14	0.36
21	1.0	1.0 : 21 : 14	0.39
22	2.0	1.0 : 10 : 6.8	0.33
23	4.0	1.0 : 5.0 : 3.4	0.31
24	7.3	1.0 : 2.7 : 1.9	0.27
25	10.2	1.0 : 1.8 : 1.3	0.29
26	14.3	1.0 : 1.3 : 1.0	0.29
27	20	1.4 : 1.2 : 1.0	0.24
28	28	2.0 : 1.1 : 1.0	0.26
29	39	3.0 : 1.0 : 1.1	0.30
30	55	5.8 : 1.0 : 1.4	0.25
31	72	12 : 1.0 : 2.3	0.18
32	100	7.4 : 0.0 : 1.0	0.14

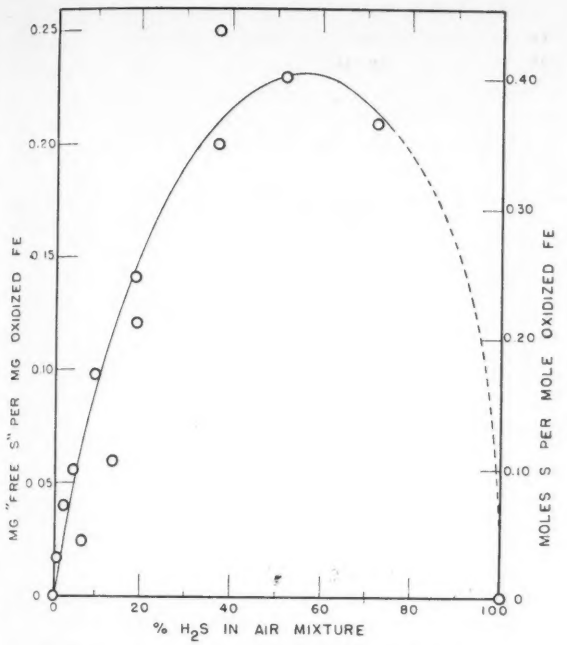

Figure 5A—Free sulfur in corrosion product of steel.

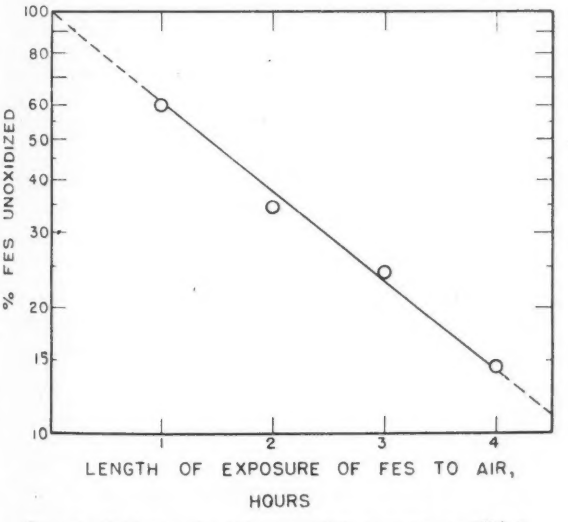

Figure 6—Oxidation of wet ferrous sulfide in moist air, 120° F.

are given in Table IV, and the results are plotted in Figure 6.

The Conversion of Hydrated Iron Oxide to Iron Sulfide and the Reverse Process

Hydrated iron oxide was formed on the surface of a steel test strip by exposure to a stream of moist air, using the alternate immersion testing apparatus. After a desired amount of oxide had formed, the steel test strip was exposed to H_2S for a period of time; then to air once again. The test strip was then treated with inhibited sulfuric acid and the H_2S was recovered and titrated. Total metal lost in corro-

TABLE II

Corrosion Rate of Wet Steel in Moist 1% H_2S—99% Air Mixture at 120° F.

No.	Duration of Exposure, Minutes	Total Weight Loss, Mg. per 2.15 Sq. In. Steel
1	15	6.5
2	30	8.9
3	60	26.3
4	120	46.5

Uniform Corrosion Rate: 0.36 inch penetration per year.

Approximate Gas Composition:

Gas	Volume, Percent	Moles per Mole H_2S
O_2	18.2	21
H_2O	12.1	14
H_2S	0.88	1.0

TABLE III

Composition of Products Formed During Corrosion of Wet Steel by H_2S-Air Mixture at 120° F for Two Hours

No.	Percent H_2S in Air Mixture (Sat'd. in H_2O Vapor at 120° F.)	Weight Ratio, Fe as Sulfide Total Fe Dissolved	Weight Ratio, "Free Sulfur" Total Fe Dissolved
1	0.22	0.084	....
2	0.87	0.128	0.017
3	2.4	0.51	0.040
4	4.8	0.25	0.055
5	6.8	0.27	0.024
6	7.5	0.30	0.098
7	13.3	0.31	0.059
8	18.6	0.36	0.14
9	18.6	0.34	0.12
10	26.0	0.54	....
11	36.4	0.63	0.20
12	36.4	0.61	0.25
13	51.0	0.50	0.23
14	71.5	0.46	0.21
15	71.5	0.88	....
16	100	0.94	0.00
17	100	0.90	0.00

TABLE IV

Rate of Oxidation of Wet Ferrous Sulfide in Water-Saturated Air at 120° F.

No.	Length of Exposure of Sulfide to Air, Hours	Percent of FeS Oxidized to Fe Oxide	1st Order Reaction Velocity Constant, k, Percent Reacted Per Hour*
1	1	40.5	51.8
2	2	66.0	53.8
3	3	76.0	47.6
4	4	85.5	48.3

$$*k = \frac{2.3}{t}\log\left(\frac{a}{a-x}\right)$$ where t = time (hours), a = initial amount of sulfide, x = amount of sulfide converted to oxide

TABLE V

Composition of Corrosion Products Formed by Alternate Exposure of Steel to Air and H_2S

No.	Initial Exposure to Air	Exposure to H_2S	Second Exposure to Air	Final Ratio, Fe as Sulfide Total Fe Reacted
1	1 hour	2 hours	1 hour	0.87
2	1 hour	1 hour	17 hours	0.56
3	3 hours	1 hour	2 hours	0.30
4	1 hour	1 hour	16 hours	0.41
5	1 hour	1 hour	17 hours	0.53
6	3 hours	1 hour	.....	0.37
7	1 hour	1 hour	1 hour	0.61

TABLE VI

Analysis of Steel Test Strips
Results of Duplicate Analyses, Wt. %

C	P	Si	Mn	S
0.21	0.02	0.11	0.85	0.04

sion was also obtained by weight loss. The results of several runs are given in Table V.

Discussion

The analysis of the test strips used in these experiments (Table VI) indicates a typical cold-rolled steel of average to slightly above average corrosion resistance. The maximum corrosion rate of this wet steel in moist H_2S-air mixture occurs at 1-2 percent H_2S, with a mole ratio of 1:10 to 1:20 H_2S to oxygen. The minimum corrosion in these tests occurs in moist air free of H_2S. There is also a relatively lower rate of corrosion in air-free H_2S.

Steel apparently corrodes in an air-H_2S mixture with the simultaneous formation of acid-soluble sulfide and oxide. It was found on analyzing the corrosion product that the percentage of iron as sulfide was always larger than the volume percentage of H_2S in the mixture causing the corrosion. Such a heterogeneous surface scale may result in a porous layer which does not prevent diffusion of fresh reactants. This possibility is suggested by the linear progress of corrosion with time (refer to Figure 4).

The rate of formation of hydrated oxide is approximately the same as the rate of formation of (ferrous) sulfide, but the interconversion of oxide to sulfide and vice-versa favors sulfide as the more stable under these conditions. This indicates that wet ferrous sulfide is definitely not spontaneously ignited, at least by moist air. Other experiments made in the laboratory but not recorded as data in this report have indicated that dry ferrous sulfide does not readily oxidize in air at room temperature. Hydrous ferric oxide is thermodynamically more stable than ferrous sulfide, but the rate of conversion is reasonably slow.

The rate of oxidation of wet ferrous sulfide proceeds fairly rapidly in moist air, as illustrated in Table IV and Figure 6. A logarithmic decrease in percent reacted as a function of time suggests that the rate is proportional to the amount of sulfide left; conceivably the oxidation rate could be proportional to surface area of sulfide. To give this result a heterogeneous sulfide layer composed perhaps of spherical particles would be required. The data fit a first order kinetic equation fairly well, and show that reaction velocity constant k is about 0.5 $hr.^{-1}$; that is, the rate at any instant is such that 50 percent of the remaining sulfide would be oxidized in one hour.

The composition of the corrosion products of steel in H_2S-air-water vapor varies with composition of the gas mixture, over the whole range of H_2S percentage. The data are more accurate in the region of dilute H_2S since such experiments could be carried out in less time than those in high H_2S concentrations.

"Free sulfur" (extractable by CS_2) is present up to very high H_2S concentrations, and increases rather than decreases with increased sulfide formation. One conclusion might be that sulfide offers a better catalytic surface for the oxidation of H_2S than does oxide. In view of the indirect method used in obtaining the free sulfur data, the accuracy of the data is probably as low as ± 50 percent.

As shown in Table V, a hydrous ferric oxide layer was formed on steel in some experiments; this layer was then exposed to pure H_2S and then air. The percentage of sulfide in the resulting corrosion product was surprisingly high. Once the oxide was converted partly to sulfide (probably a mixture of FeS, Fe_2S_3), subsequent exposure to air caused relatively little additional formation of oxide. All the results reported here agree in general with those of related experiments performed elsewhere, as discussed above.

Summary

1. For mild steel, the most corrosive H_2S-air mixture consists of about 1 percent H_2S in water-saturated air.
2. At H_2S concentrations of about 10 percent, the corrosion rate increases about 20 percent when the temperature is increased from 70° F to 120° F.
3. The corrosion rate under the conditions tested is independent of time, at least during the first several hours exposure.
4. Analysis of the corrosion products reveals a fairly uniform increase in percent sulfide with increase in H_2S concentration. Free sulfur is present even at high H_2S concentrations.
5. The oxidation of wet ferrous sulfide is 85.5 percent complete after four hours exposure to air at 120° F. Ferrous sulfide as prepared in these experiments does not ignite spontaneously in air.
6. The conversion of hydrated iron oxide to iron sulfide (in the presence of hydrogen sulfide) proceeds faster than the conversion of iron sulfide to iron oxide (in the presence of air), under the conditions used in the experiments.

References

1. C. G. Milbourne and W. J. Huff, "Humidity Effects in the Iron Oxide Process for the Removal of H_2S from Natural Gas," *Ind. Eng. Chem.*, **22**, 1213, (1930).
2. T. G. Pearson and P. L. Robinson, "Reaction Between $Fe_2O_3 \cdot H_2O$ and H_2S," *J. Chem. Soc.*, 814, (1928).
3. G. U. Hopton, and R. H. Griffith, "Removal of H_2S from Fuel Gases," Inst. Gas Engrs. Commun. No. 288, also *Gas World*, **123**, 588.
4. P. V. Geld and O. A. Essin, "Sulfide Corrosion of Iron," *J. Applied Chem.*, (USSR), **19**, No. 9, 861, (1946).
5. G. Ballabio and G. Pastonesi, "Action of H_2S on Steels," *Met. Ital.*, **31**, 431, (1939).
6. J. M. Devine, C. J. Wilhelm and L. Schmidt, "Effect of O_2 on Gaseous H_2S Corrosion of Tank Steel," Bur. Mines R. I. 3160, Feb., 1932.

DISCUSSION

Comment by F. A. Prange, Phillips Petroleum Co., Bartlesville, Okla.:

While it is commonly assumed that the corrosion products in hydrogen sulfide environments are FeS,

this point must be demonstrated. Using X-ray diffraction, we have yet to find FeS in sulfur-containing corrosion products. Pyrites, however, are a common constituent. It would add to the study of corrosion if corrosive conditions producing FeS were enumerated.

Comment by Lyle R. Sheppard, Shell Pipe Line Corp., Houston, Texas:

I am glad to see that interest is being taken in the vapor space corrosion in sour crude oil tanks. To date this has proven to be one of the most difficult corrosion problems to solve. Work such as Messrs. Bond and Marsh are doing will give us a better understanding of the mechanism and hence a quicker solution of the problem.

I have a few comments on their paper, and observations from work we have done which may be beneficial to them.

During the process of converting the iron sulphides to hydrogen sulphide by the addition of sulphuric acid there is a good possibility of forming "milk of sulphur." Since this form of sulphur is not soluble in carbon disulphide it would not show in the results as either free sulphur or hydrogen sulphide. It might be well to check this by determining if any free sulphur settled from the test solution upon standing for 24 hours.

In the tests it was found that the percentage of sulphur to oxygen in the iron corrosion products was always greater than the percentage of sulphur to oxygen in the original corrosive vapor mixture. There are two possible explanations of this. First, it could mean that hydrogen sulphide has a greater affinity for iron than oxygen. Second, it could mean that part of the oxygen formed water by uniting with the hydrogen liberated in the iron-hydrogen sulphide corrosion process. This second explanation is rather important for it means that perfectly dry hydrogen sulphide, which is non-corrosive to iron, could become corrosive upon this water formation by the addition of oxygen. Slow oxidation of the dry hydrogen sulphide by oxygen ($2H_2S + O_2 \rightarrow 2H_2O + 2S$) could form the initial water. Once this water was present more hydrogen would become available and thus more water formed. The corrosion would become progressively greater.

We have found in a number of examinations of the iron corrosion products taken from the vapor space of sour crude oil tanks that oxides and free sulphur were predominant with surprisingly little sulphides. This was not always due to oxidation of the sulphides after removal from the tanks. These corrosion products were very corrosive to iron in brine solutions. Droppings from the vapor space area can cause severe damage in the brine area on the tank bottoms. This has been verified by experience. Thus if corrosion is stopped in the vapor space area at least part of it will be stopped in the brine area.

Most of our work with sour crude oils has been in pipe lines rather than tanks. However, knowledge of a few of the observations from pipe line work may give leads for further investigation in tanks. A typical oxidized sediment from pipe lines had the following analysis by weight:

FeS and Fe_2O_3	36.9%
Fe_3S_4 (magnetic)	43.6
Fe_3O_4 (magnetic)	9.2
FeS_2 and S	7.1
Sand	3.2
	100.0%

The important part of this analysis is the presence of magnetic iron sulphides. It was also present in large percentages in unoxidized sediment (by atmosphere). We know it was magnetic because it was separated from the other sulphides magnetically. We know it was a sulphide because hydrochloric acid evolved hydrogen sulphide from it. We know it was one of the original corrosion products because it was found in unoxidized sediment and was reproduced in the laboratory from hydrogen sulphide and iron. We have never isolated ferric sulphide from the sediment. It may have been present, but changed to ferrous sulphide and free sulphur.

The following table gives the average penetration rate on iron from a number of tests of the various sulphur products found in pipe line sediment. These were 96-hour tests in synthetic brine solutions. The oxidized tests were made with the products moistened with brine and then exposed to the atmosphere for 24 hours before the tests began. Agitation during the tests gave higher rates than these shown.

	Average Penetration Rate Mils per Year	
	Unoxidized	Oxidized
H_2S	12.8	....
FeS	5.3	16.5
Fe_3S_4	119.6	603.0
FeS_2	32.0	146.8
S	1120.0	....
Pipe line sediment	211.7	778.0

(The synthetic brine used was an average of many natural brines made by Shell Development Co. It is NaCl — 7.0 gr., Na_2SO_4 — 0.3 gr., $CaCl_2 \cdot 2H_2O$ — 0.74 gr., $MgCl_2 \cdot 6H_2O$ — 0.85 gr., and distilled water 100 cc.)

Because of these studies we came to the conclusion that magnetic iron sulphide and free sulphur were the two greatest offenders in pipe line corrosion by sour crude oil.

Authors' Reply:

Mr. Prange is justified in questioning the composition of the corrosion product in our experiments.

It appears that there are three products possible which contain iron and sulfur: ferrous sulfide (FeS), iron pyrite (FeS_2) and ferrous sulfide with sulfur held "in solution" (FeS_x, where x may vary from 1.0 to about 1.33).

Iron pyrite is not soluble in dilute acid, such as the

10 percent sulfuric acid used in our tests, so the H_2S and free sulfur observed could not have been derived from pyrite. There was no visible residue after pickling with acid and extracting with CS_2, so the amount of pyrite present, if any, was small.

Various iron sulfides are reported in the literature having atomic ratios of S/Fe continuously variable from 1.00 to at least 1.33.[1] X-ray analysis of such sulfides reveals an FeS crystal lattice with random sulfur atoms held "in solution" in the lattice structure.[2] These sulfur atoms are not dissolved by carbon disulfide. When dissolved in acid, sulfur-bearing sulfides form H_2S and the excess sulfur is precipitated.[3]

These sulfur-bearing ferrous sulfides might have been present in our corrosion product. This possibility was tested in a number of experiments, similar to those described in our paper; in these experiments a CS_2 extraction was made before as well as after acidification of the corrosion product. In the second extraction the CS_2 dissolved some of the organic inhibitor used in the acid; this inhibitor was removed with alcohol, which dissolved a negligible amount of sulfur.

Such experiments were carried out on scale formed in 1, 20, 50, and 100 percent H_2S-air mixtures. Table A gives the data obtained in these tests.

It is seen that most of the free sulfur is extractable by CS_2 before acidification of the scale, so it appears that the corrosion product is principally a mixture of ferrous sulfide and elemental sulfur, with some iron oxide.

The "milk of sulfur" to which Mr. Sheppard refers was not produced in the experiments. Trial runs were made to determine whether the carbon disulfide was quantitatively dissolving the sulfur and this was found to be the case.

Mr. Sheppard's other comments are very interesting. The magnetic sulfide Fe_3S_4 to which he refers is probably one of the compounds containing FeS with additional sulfur atoms held "in solution" in the crystal lattice. Such compounds are known to be magnetic even though all the iron is in the ferrous state.[4]

References (for Discussion)

1. J. W. Mellor, Inorganic and Theoretical Chemistry, **XIV,** 138, (1935 ed.).
2. C. Fontana, *Atti. acad. Lincei* (6), Vol. **5,** p. 579 (1927). Cf. *Chem. Abst.* **21,** 2405[9] (1927).
3. Mellor, op. cit., quoting: F. von Schaffsgotsch, *Pogg. Ann.* **50,** 333, (1840). C. Bodewig, *Zeit. Kryst.,* **7,** 179, (1883). H. Habermeyl, *Ber. Oberhess. Ges. Nat. Min.,* 609, (1876).
4. H. Miyahara, *Proc. Phys. Math. Soc. Japan,* **22,** 358, (1940). Cf. *Chem. Abst.* **34,** 6497[9] (1940).

TABLE A

Free Sulfur in Corrosion Scale

Percent H_2S in Air Mixture	Percent of Dissolved Iron Present as FeS	Mg. Free S in Scale Before Acid Treatment, per Mg. Dissolved Fe	Mg. Free S Formed by Acid Treatment of Scale per Mg. Dissolved Fe
1	7.2	0.04	0.00
20	42	0.11	0.03
50	68	0.20	0.03
100	100	0.00	0.00

The Cost of Corrosion to The United States ★

By HERBERT H. UHLIG*

ECONOMIC and material loss through corrosion of metals is divided into a) direct loss resulting from protection costs and replacement of corroded equipment and b) an incalculable, often higher, indirect loss through shutdown, over-design, loss of product and efficiency, explosion, and contamination.

Direct loss by corrosion, although amenable to analysis, still is difficult to estimate. A survey of this kind is almost always incomplete and is subject to a wide range of interpretation. Nevertheless, it is believed that annual cost to the United States, tabulated later in detail and amounting to over $5500 million, represents the present-day tax exacted directly by the ravages of corrosion and is the correct order of magnitude. Previous estimates in the order of $500 million to $1000 million are definitely too low.

Not all of the material loss can be prevented. Metals persist in reverting to their ores or to compounds of lower energy despite corrosion protection; and possible reduction of economic loss is limited by the continuous or periodic upkeep required of all protective measures. Notwithstanding, much more can be accomplished through further scientific and engineering application to this problem, involving, as it does, conservation of materials and human effort.

The substance of this report may well serve to challenge the imagination of those responsible for administration of research. If this is true, perhaps the facts will also challenge engineers and scientists, persuading them of the opportunities for service in a field where only 1 percent improvement means the annual saving of $55 million and thousands of tons of critical metals.

Indirect Losses

Indirect losses cannot be estimated and are not subject to even an educated guess. This is particularly true since they include loss of life and limb, and psychological factors attending unpredictable failure or explosion. Furthermore, losses of materials and of dollars and cents through corrosion of industrial equipment seldom become public information. Enough convincing examples are on record, however, to show that these losses are a high order of magnitude.

For example, leakage from a corroded pipe line may cause spillage of large amounts of gas or petroleum. If fire catches, buildings in congested areas may be affected, or in some cases the petroleum may leak into a water reservoir contaminating an entire municipal supply. An extreme example of this kind is recorded relating to a 40-mile gas distribution pipe line so badly corroded that 90 percent of the gas which entered was lost through perforations in the pipe.[1]

Other examples relate to water mains. Corrosion causing bursting of a pipe may shut off vitally needed water to sections of a city, or, what is more general, rust and tubercles gradually choke off the supply, necessitating increased pumping capacity until the line is cleaned or replaced. Reduction in capacity of water mains because of corrosion has been estimated as costing the United States almost $40,000,000 annually.[2]

The cost of shut-down through corrosion is also a large figure. In oil refineries, replacement of corroded tubes in one unit alone may cost $800 per hour because of lost production.[3] Corroded boiler tubes or condensers of a large public utility may cost the company $10,000 per day for power bought from an adjacent system while the corroded unit is repaired.[3]

Spoilage of food in corroded tin containers has amounted, at times, to over $1,000,000 loss per year to one company alone. Nor have such losses been overcome. A lesser loss but of the same order of magnitude was sustained recently by a company using metal covers to seal glass jars. Additional instances of indirect loss are on record, but many more are never analyzed or never reported. Their total would increase the costs of corrosion tabulated in this report by a substantial factor.

Losses Incurred Through Over-Design

Large as are these more obvious indirect losses, there are also similar losses less readily recognized. For example, appreciable tonnages of metal are consumed needlessly each year because equipment is over-designed to take care of corrosion. Because corrosion rates may be unknown, the design engineer often specifies several times the required thickness of metal to ensure adequate strength and continued performance. Except for corrosion, the factor of safety might be much less. Over-design is common with construction of reaction vessels, boiler and condenser tubes, buried pipe lines, oil-well sucker rods, water tanks, and marine structures.

The magnitude of this factor can be appreciated by reviewing the design of pipe lines carrying natural gas and petroleum. Pipe lines laid without protection are provided with walls exceeding the thickness required for operating pressures. The thicker wall is for the purpose of avoiding early perforation by

★ Experience Paper presented before United Nations Sectional Meeting, Mineral Resources 6 (a), on Conservation by Corrosion Control, at Lake Success, N. Y., September 1, 1949. The major portion of this material was published in *Chemical and Engineering News*, **27**, 2764-67 (1949) Sept. 26.

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corrosion from the outside. With adequate external protection, however, the wall thickness can be reduced 20 to 35 percent. This will still allow an ample factor of safety with regard to internal pressures. For example, 225 miles of 8-inch-diameter pipe reduced in wall thickness from 0.322 to 0.25 inch saves 3700 tons of steel, valued at $330,000 in 1945.[1]

This saving amounts to as much as or more than the usual combined cost of a protective coating plus cathodic protection which permits thinner wall pipe.

The reduction of wall thickness, incidentally, also provides a larger internal diameter pipe having approximately 5 percent increase in capacity. This makes possible additional gains over the initial saving of steel. Based on the length of all pipe lines in the country, a 5 percent increase in capacity is equivalent to almost 50,000 miles of pipe.

Another example is given by fabricated sucker rods used in oil wells. As fabricated, the cost is at lease 35 cents per foot, accounting for an annual figure of $14,000,000 based on a total production of 40,000,000 feet of rod in 1945.[4] It is estimated that probably $7,000,000 of this total can be ascribed to "over design" to take care of corrosion fatigue, since without this deteriorating factor the rods might be made lighter in weight and without alloying additions. Further indirect loss results from the extra power required to operate the heavier design rods and from the extra expense in recovering the heavy rods after breakage.

Direct Losses

Estimated annual direct losses by corrosion to the United States are listed in Table I. The losses are calculated on the basis that all measures which apply to the protection of metals, or which increase the cost of materials over that of steel, should be included. Labor charges for application or replacement are considered part of the costs.

The individual estimates include only an order of magnitude appraised from the best available information. Lack of data, either unobtainable at the time of writing or, in a few instances, not available as public information, compelled some important omissions. The final cost figure of Table I, in any case, should be considered on the low side, since it is felt that future, more exhaustive attempts to estimate true costs will raise this total appreciably.

Although all common metals corrode, iron and steel account, by a large factor, for most metal in use. Corrosion losses, therefore, obviously reflect this situation. Were iron completely resistant to rust and tarnish, it undoubtedly would be used generally because of its availability and low cost. Therefore, whenever nonferrous metals or alloy steels are used instead primarily to resist corrosive attack, the increased cost over iron of the same shape and size is a legitimate charge to corrosion. One weakness in this argument comes from the fact that resistant nonferrous or alloy materials are usually used in thinner gage or thinner sections than corresponding steel construction, so that labor charges per pound of metal may be more than those for an equivalent weight of steel. For this reason, metal production figures on a weight basis multiplied by a differential price per pound are not necessarily a correct measure of corrosion costs applicable to a given metal. This factor, however, would probably not alter by much the final cost figure of Table I.

TABLE I. Annual U.S. Direct Loss by Corrosion Including Cost of Corrosion Control

1. Paints, varnishes, and lacquers for protecting metals, based on 0.5 total estd. production for 1948	.....	$ 585,000,000
Ratio labor costs of application to cost of paint = 2.5 to 1	.....	1,460,000,000
2. Phosphate coatings; materials and applications	.....	20,000,000
3. Galvanized sheet, pipe, and wire	.....	136,500,000
1,643,000 tons sheet in 1948 at 2.5 cents/lb. differential over black iron	$ 82,000,000	
830,000 tons of galvanized pipe (1947) at 2.5 cents/lb. differential	41,500,000	
259,000 tons of galvanized barbed wire (1947) at 2.5 cents/lb. differential	13,000,000	
Total	$136,500,000	
4. Tin and terne plate; 3,950,000 tons in 1948 at 4 cents/lb. differential over black iron sheet	.....	316,000,000
5. Cadmium electroplate	.....	20,100,000
Cd production (1948): 7,200,000 lb.; 60% for electroplating: 4,300,000 lb.		
Application $2.66/lb. (based on Ni application cost)	8,600,000	
At $2.00/lb.	11,500,000	
Total	$ 20,100,000	
6. Nickel and nickel alloys		182,000,000
Electroplate, 30,000,000 lb. nickel (1948) at 40 cents/lb	$ 12,000,000	
Application cost	80,000,000	
	$ 92,000,000	
Heat- and corrosion-resistant alloys other than stainless alloys listed below, 180,000,000 lb. (1947) at 50 cents/lb	90,000,000	
Total	$182,000,000	
7. Copper and copper-base alloys; 250,000,000 lb. (1948) of copper and alloy pipe and tube at 20 cents/lb. differential (recent data on other applications not available)	.....	50,000,000
8. Stainless chromium-iron and chromium-nickel-iron alloys		620,400,000
Wrought alloys, 600,000 tons (1948) at 50 cents/lb	$600,000,000	
Castings, 20,400 tons (1948) at 50 cents/lb	20,400,000	
	$620,400,000	
9. Boiler and other water conditioning	.....	66,000,000
10. Underground pipe maintenance and replacement*	.....	600,000,000
11. Oil refinery maintenance	.....	50,000,000
12. Domestic water heater replacements, 30,000,000 tanks, 10% replacement each year at $75 each for labor and materials	.....	225,000,000
13. Internal combustion engine corrosion	.....	1,030,000,000
Corrosion estd. responsible for 60% of wear; 38,000,000 vehicles (1948), 10,400 miles/year/vehicles; valve grind costof $40/30,000 miles; piston ring and overhaul cost of $150/50,000 miles.:		
Mufflers, 4,750,000 installed in 1948 at $14 each	.....	66,000,000
GRAND TOTAL		$5,427,000,000

* Based on 988,000 miles of gas, water and oil lines, employing estimate of K. H. Logan that $200,000,000 is reasonable annual cost for 500,000 miles of pipe line. Logan's figure has been increased 50 percent to take care of increased labor and material costs.

The assumption that 50 percent of the annual production of paints is used for protecting metals against corrosion may be either high or low, since no data are collected bearing on the specific surfaces to which paints are applied.

The estimate for phosphate coatings, used largely on steel as a base for paints, was obtained from the largest concern that produces phosphating solutions.

To the approximate $2.5 billion charge to corrosion listed in Table I for various coatings should be added similar charges for the enameling industry and for the rubber and plastic coatings field, figures for which were not available. Estimates are also omitted for electrodepositing several metals in addition to those listed.

The data for copper and copper-base alloys omit applications such as flashing on buildings, air-conditioning equipment, automobile radiators, refrigeration equipment, etc., for which recent data are not available.

The estimate of $66 million as the cost of boiler and other water conditioning was obtained by multiplying the total horsepower capacity of the country by the cost of water conditioning plus labor and boiler tube replacement per unit of horsepower.[5]

Underground pipe maintenance costs make use of an earlier figure carefully estimated by Logan[6] and corrected for increased costs and for the re-estimated pipe-line mileage.[7]

Oil refinery maintenance costs, including both materials and labor, should be corrected for materials listed elsewhere. However, labor costs predominate, and it is likely that indirect losses—for example, shutdown—combine to make the $50 million estimate too low. Also, to this figure should be added several million dollars more for tanker corrosion, oil-well corrosion, distribution equipment losses, and other items, data for which were not obtainable.

Combined losses of the chemical industry, communications industry, railroads, shipping, etc., might bring the total to 10 or 20 times the corresponding figures for the oil industry. However, data reflecting so much as an order of magnitude could not be obtained for general corrosion losses in industry.

Cost figures for hot-water tank replacements are derived from service data of the Federal Public Housing Authority quoted by Waldron.[8] One-fourth to one-half million domestic hot-water tanks and range boilers at various housing projects throughout the country, using all types of waters, were observed for five years. Within this time, several projects required annual replacement of as high as 25 percent of all tanks in service, with a figure of 10 percent reflecting a conservative estimate. Industrial water tanks are not included in the final cost figure.

The large cost of engine wear attributed to corrosion is startling, but nevertheless appears to be correct. Recent experimental data obtained both in England[9] and in the United States[10, 11] prove that piston rings and cylinder walls wear not only by abrasion of one part moving on the other but also by chemical attack of combustion products. Corrosive wear was found to be especially active during the warming-up period of engine operation when water condenses on the cylinder walls.

Experiments were conducted in 40- to 100-hour tests in which piston rings were weighed before and after, and the internal diameter of cylinders precisely calipered. The conclusive evidence of corrosive wear is briefly as follows:

1. Cylinder-wall temperature of 104° F (40° C) or 120° F (50° C) was followed by considerably more wear (in some cases a factor of 5 to 1) than at temperature of 167° F (75° C) or higher.
2. Using hydrogen as fuel with low cylinder-wall temperatures caused substantially less wear than using gasoline or alcohol blends. Combustion products of the latter contain carbonic acid, various organic acids, and sometimes sulfuric acid.
3. Wear increased proportionally to the sulfur content of the fuel.
4. Acids were detected in the combustion products. Sulfuric acid and metal sulfates were detected in cylinder deposits and in used lubricants.
5. Reduction in wear was obtained by the use of corrosion-resistant alloys.
6. Substantial reduction in wear was obtained by adding alkaline compounds to oil or fuel, or by passing oil over lime pellets.

The factor of corrosive wear is borne out, as well, by service data. Statistics compiled in England show that cylinder wear for long-distance runs amounts to about 0.001 inch per 5000 miles, whereas for automobiles used by doctors and some house-to-house delivery vehicles (more cylinder condensate) the wear was 0.001 inch per 100 to 1000 miles, a maximum ratio of 50 to 1.

From these and other facts it appears reasonable to estimate[12] that an average of 60 percent of all automobile engine wear can be attributed to corrosion.

Mufflers on automobiles, in the majority of instances, fail by corrosion. There were 4,740,600[13] mufflers installed by car dealers and independent repair shops in 1948. This does not include mufflers installed at gasoline filling stations, fleet shops, or by individual car owners. The above figure, therefore, multiplied by an estimated $14 for labor and parts gives a conservative estimate of this source of loss from corrosion.

Reduction of Corrosion Costs

What can be done to reduce these losses? Certainly development of present methods and research on new approaches to corrosion control can be depended upon to exert their effect. For this reason, many costs of Table I can be expected to contract in the future. On the other hand, others will increase, reflecting savings largely of indirect corrosion losses not tabulated in this survey.

Obviously, since iron and steel constitute the bulk of metal in use, paints and metal coatings will continue as major protective measures. The improvement of their protective qualities has received considerable impetus through the expansion of research facilities in the industries. Much more remains to be done, however. It is not an unreasonable objective for a research program in this field to improve some or all of these coatings by more than 10 percent within the next five years. Protective paints, for instance, have improved in excess of this factor within recent years, largely through the use of new vehicles and corrosion-inhibitive primers. Along with future advances, there is urgent need for accompanying quantitative data on the life of painted metal structures. Service data of this kind are peculiarly lacking at the present time.

The use of corrosion-resistant metals and alloys is expected to expand because of economies effected by their use. Another factor in this same direction is the increasing acceptance of bright metal surfaces for many decorative applications. The economic advantage of replacing iron by corrosion-resistant metals or alloys is not always realized. For instance, Pogacar[14] gives an example of alternate materials available for

use in heat-exchanger tube bundles used in the coke industry. Carbon-steel 13-gage tubes cost $3190 and last one year. Stainless tubes of the same gage cost much more—namely, $13,600—but they last 20 years. The cost per year of $3190 for carbon steel but only $680 per year for stainless steel reflects a saving of $2500 per year plus the conservation of many pounds of iron over a 20-year period.

In general, whenever a more costly alloy or protective coating increases life of the metal structure and labor costs are identical, the substitution, if economically sound, can be estimated by evaluating the following expression:

$$100\,\frac{\Delta T}{T}\left(1+\frac{L}{C}\right)-100\,\frac{\Delta C}{C}$$

where T = life in years
L = labor costs for replacement
C = cost of materials
ΔC = increase in cost using new material or protective coating having increased life ΔT

$100\,\frac{\Delta T}{T}$ = % increase in life

$100\,\frac{\Delta C}{C}$ = % increase in materials cost

If this expression is greater than zero, the substitution saves money, the amount of which per year can be obtained by multiplying the expression by

$\frac{C}{100\ (T+\Delta T)}$ This annual gain neglects interest charges.

Cathodic Protection

Buried pipe or other metal structures can be protected externally for an almost indefinite period by use of cathodic protection. Pipe lines so protected show no evidence of attack after many years of service. Cathodic protection makes use of electric energy supplied from some source such as a rectifier or wind-driven generator. The negative terminal of the source is connected to the pipe, the positive terminal to an anode bed. The latter is made up of carbon or graphite which gradually disintegrates or oxidizes, or scrap iron which corrodes to an extent approximately proportional to the impressed current.

Cathodic protection without use of external electric current is possible employing "sacrificial" anodes of magnesium, aluminum, or zinc. Anodes of these metals set up a galvanic cell with the steel structure, resulting in electric current that acts similarly to protect the steel from corrosion. Transfer of corrosion from the pipe or other structure to the readily accessible anode bed requires that the latter be renewed at intervals depending on the amount of electricity flowing. Rates of corrosion of sacrificial anodes are somewhat higher than the chemically equivalent weight of iron that otherwise rusts.

Possibilities of Various Metals

Zinc, being a critical metal, offers relatively little hope for this purpose from a conservation standpoint. Aluminum ores are more abundant, and magnesium is available in apparently unlimited quantities in ocean water. Since aluminum or magnesium recovery requires definite quantities of electric energy per pound of metal, employing these metals for cathodic protection is simply that of a convenient source of energy at the site where corrosion takes place. For example, each pound of magnesium in a sacrificial anode is equivalent to about 500 ampere hours.

Conservation of steel by cathodic protection, therefore, throws a corresponding load on our energy resources and on cheap forms of some metals or conducting nonmetals. The energy requirements, however, are relatively small and are entirely reasonable in view of the otherwise serious loss of product, such as oil or gas, that may occur in absence of corrosion protection. Furthermore, the initial saving of steel made possible by thinner-wall steel pipe cathodically protected is a major factor when one deals with thousands of miles of pipe line.

When scrap iron is used as anode, this is continually consumed, so that, except for the initial saving of steel by use of thinner wall, iron as such may or may not be conserved. This fact suggests the need for improved graphite or other types of insoluble anode beds available for installations employing impressed current.

Installation and Maintenance Considerations

Costs for installing and maintaining cathodic protection vary with the method, soil conditions, type of protective coating, if any, and other factors. Use of a supplemental nonconducting coating has been found to be justified economically. It acts to distribute better the protective current to critical areas of exposed steel and reduces current requirements and maintenance costs. For some installations on pipe lines employing supplemental coatings, initial investment costs have been between $150 and $600 per mile.[1, 15] Sacrificial anodes of magnesium weighing 17 pounds cost from $7.50 to $10.50 each, depending on quantity, and last approximately 10 years when supplying 90 milli-amperes of current continuously. At one installation it is reported that labor costs amounted to 70 percent of the cost of magnesium anodes.[16] Maintenance costs vary widely. A figure of 1 percent of the initial investment for the pipe line, which includes power costs, depreciation, interest, and taxes, was given as an average annual estimate for a Pacific Coast gas line observed over a five-year period.[15]

Cathodic protection also applies to submerged structures, industrial water storage tanks, and domestic hot-water tanks. At the Panama Canal, steel gates measuring 75 feet high, 65 feet long and 7 feet thick, painted with bituminous enamel, are cathodically protected using an impressed current of approximately 1 ampere per 1000 square feet of surface.[17] The initial cost for installing cathodic protection using steel anodes was $1000 per gate or $200 per 1000 square feet of protected surface. This cost is estimated as less than 0.5 percent of the cost for replacing the gate. In operation after four years, no pitting was observed, and the protection is expected to permit operation of the locks until 1953 without painting.

Use of magnesium anodes for domestic hot-water

tanks has gained headway during the past few years, and it now seems apparent that at least several years' life can be added to galvanized hot-water tanks. Use of rectifiers and insoluble anodes has also offered promise, particularly for industrial water tanks.

Other Protective Measures

Increased use of inhibitors for cooling systems, pipe lines, brine systems, air-conditioning equipment, heating plants, small boilers, and others, will reflect eventually the conservation of thousands of tons of steel and other metals. An inhibitor in a petroleum product line, for example, is estimated to increase average capacity by 15 percent.[18] Cost of the inhibitor is usually a small consideration.

Deaeration of waters to protect steam boilers is practiced by all modern plants. Deaeration is now also available for reducing corrosion by cold water. Equipment has been quoted as costing $10,000 for a 1,000,000-gallon-per-day plant or $200,000 for a 50,000,000-gallon-per-day plant. Corresponding operating costs are about $2.00 per million gallons when dissolved oxygen is reduced to one part per million.[19] This cost will be higher when corrosion must be held to a minimum and dissolved oxygen, therefore, must be reduced still more.

Reduction of Engine Wear

Present data show that the economic loss represented by corrosive wear of engines can be reduced by available protective measures, such as addition of inhibitors to oil or fuel, and by use of corrosion-resistant alloys for cylinder liners and piston rings. Protective measures of this kind should effect an eventual saving of at least 50 to 95 percent of present cylinder and ring wear caused by corrosion alone. This is equivalent to a minimum 30 percent reduction in the over-all wear from combined corrosion and abrasion, with possible improvement over this estimate.

Valves and valve seats will probably not be inhibited by the same additions to fuels that protect cylinders and rings, but there is every possibility that current improvement of oxidation-resistant alloys will make available, in due course, valves having still longer life.

Present-day loss of mufflers probably can and will be mitigated by use of protective coatings instead of heavier-gage steel now used in more expensive types. This approach will save steel.

Proposed Research Program

Speculation about the future, if purely guess work, may or may not justify the effort required. However, continual thoughtful planning for the future, based on established facts and past experience, is necessary to human survival. For this reason, a summary of predicted reasonable gains to be made by a well directed research, development, and educational program over the next five years may serve some purpose. This is done in Table II. An investment of 0.5 to 1 percent of the amount to be saved would provide adequate support for such a program.

TABLE II. Predicted Annual Savings by Five-Year Research, Development, and Educational Program on Corrosion Control

1. Paints, varnishes, and lacquers, 10 percent improvement in life	$205,000,000
2. Galvanized sheet, pipe, and wire, 10 percent improvement in life	13,700,000
3. Nickel electroplate, 10 percent improvement in life for given thickness of coating applied to 30,000,000 lb. nickel at 40 cents/lb.	1,200,000
4. Increased use of inhibitors and water conditioning	200,000,000
5. Buried and submerged structures, maintenance and replacement of (20 percent saving over cost of coatings and cathodic protection for distribution and transmission pipe lines, buried tanks, canal locks, marine structures, etc.)	120,000,000
6. Domestic hot-water tank replacements, 25 percent saving over cost of cathodic protection	55,000,000
7. Internal combustion engines, 30 percent improved life through use of corrosion-resistant metals or alloys and corrosion inhibitors in oil and gasoline	310,000,000
8. Auto mufflers, 25 percent improved life	17,000,000
Total	$921,900,000

The savings, of course, are not alone in dollars and cents. There are direct and indirect savings of metals, coal, oil, water, and other of our exhaustible material resources. And not least, there is a substantial saving of human effort. What potential advance in culture and other real values of living are possible by the latter saving is a subject that lies outside the scope of this paper. It is sufficient to know that the increasingly successful effort to combat corrosion represents social and material gain for mankind.

Acknowledgment

In assembling data for this survey, the writer received help from many sources. Acknowledgment is especially due F. N. Speller, Aaron Wachter, F. L. La Que, R. J. McKay, E. P. Partridge, I. A. Denison, J. M. Pearson, M. G. Fontana, W. Blum, J. Harwood, J. A. Miles, O. C. Mudd, Ivy M. Parker, Sibyl Warren, V. M. Darsey, Marc Darrin, and the National Paint, Varnish, and Lacquer Association, American Iron and Steel Institute, Copper and Brass Research Institute, U. S. Office of Domestic Commerce, Alloy Casting Institute, *American Metal Market*, and *Motor Service*.

Literature Cited

1. Stirling, J. C., *Corrosion*, **1**, 19 (March, 1945).
2. H. E. Jordan, *Corrosion*, **3**, 369 (1947).
3. E. P. Partridge, Private Communication.
4. R. J. McKay, Private Communication.
5. Speller, F. N., Private Communication.
6. Logan, K. H., "Underground Corrosion," Bureau of Standards Circ. C450, p. 7 (1945).
7. "Correlating Committee on Cathodic Protection," *Corrosion*, **4**, 6 (Sept., 1948).
8. Waldron L. J. *Ibid.* **3**, 591 (1947).
9. Williams, C. G., "Collected Researches on Cylinder Wear," Inst. of Automobile Engrs., Automobile Research Committee, England (Jan., 1940).
10. Cattaneo, A. G., and Starkman, E. S., "Fuel and Lubrication Factors in Piston Rings and Cylinder Wear," Shell Development Co., Emeryville, Calif., paper delivered at M.I.T. Lubrication Conf. on Mechanical Wear, 1948.
11. Bruce, C. S., Duck, J. T., and Pierce, A. R., *J. Research Natl. Bur. Standards*, **41**, 144—5 (1948).
12. Wachter, A., private communication.
13. Toboldt, W. K., *Motor Service Mag.* Private Communication.
14. Pogacar, C. F., *Steel*, June 7, 1948.
15. Wright, S. A., *Gas*, p. 38 (May, 1945).
16. Hart, P., and Osborn, O., *Petroleum Engr.*, **17**, No. 12, 136 (1946) (Aug., 1946).
17. Miles, J. A., "Cathodic Protection of Lock Gates of the Panama Canal," Office Engineering Div., Panama Canal Zone. Paper presented at Symposium on Corrosion sponsored by Corrosion Sub-committee of the Deterioration Prevention Committee, Washington, D. C., Feb. 3 and 4, 1949.
18. Wachter, A., Private Communication.
19. Hoover, C. P., *Corrosion*, **3**, 185 (April, 1947).

Mechanism of Oxygen Reduction At an Iron Cathode*

By WALTER A. PATRICK* and HERMAN B. WAGNER*

Abstract

Mechanism of the anodic corrosion process is discussed. The paper refers to previous articles wherein hydrogen peroxide was assumed to be an intermediate in the corrosion reaction, particularly where ferrous materials are involved. Discusses experiments with iron-amalgam cells with a description of the procedure and diagrams of apparatus. Tables are included with present data on current, current density, percent absorption upon cathode solution and percent yield of hydrogen peroxide. An inspection of these data show that the greatest yields of peroxide were obtained in alkaline solutions with small current densities. Results indicate that possibly hydrogen peroxide also was formed in the acidic solutions but was more quickly reduced further to the hydroxyl ion which reacted to form water. A possible explanation is given of the instability of hydrogen peroxide in the acid as contrasted to its greater stability in the alkaline solution. Results obtained with those from previous parallel experiments are compared.

A GREAT deal has been written concerning the mechanism of the anodic** corrosion process. On the cathodic side much less is known, and although it is generally recognized that where oxygen is the oxidizing agent hydroxide ion is ultimately produced, the mechanism and reaction preceding its formation are not often considered.

The assumption that peroxide is in general the first product of oxygen reduction is not new. In discussing the potential of the oxygen electrode and its well noted irreversibility, G. N. Lewis[1] explains the effect of addition of hydrogen peroxide to the liquid about the oxygen electrode in diminishing the electromotive force of the cell by postulating hydrogen peroxide as a product of the electroytic reaction. Experiments by M. Traube,[2] Richarz and Lonnes,[3] Fischer and Priess,[4] Risenfeld and Solowzan,[5] Furman and Murray,[6] and others have established hydrogen peroxide as a product of oxygen reduction at cathode surfaces representing a variety of metals.

There are several possible explanations of the failure of many experiments to show definitely the formation of hydrogen peroxide as a corrosion intermediate, particularly where ferrous materials are involved. First, at the currents existent in ordinary corrosion only small amounts would be formed; secondly, that which is formed is liable to further reduction; thirdly, any ferrous or ferric ions or compounds produced concurrently or present on the iron surface initially can catalytically decompose peroxide; and lastly, as considered by Weiss,[7] even metallic iron may catalytically decompose peroxide by initiating a free-radical chain reaction.

Wieland and Franke[8] performed experiments in which iron amalgams (actually colloidal dispersions of iron in mercury) were shaken with solutions at various pH values. They showed that as one moved from lower to higher pH values greater yields of peroxide were obtained. Experiments which they conducted with finely powdered iron gave uncertain results. These experiments are of particular interest in that iron is directly involved, and it was thought desirable to investigate further the mechanism of peroxide formation with the iron amalgams.

Experiments With Iron-Amalgam Cells

The cell for these experiments was constructed of glass as shown in Figure 1. In deoxygenating the solutions specified as such below the method described by the authors in a previous paper[9] was employed.

(a) Cell: Fe-Hg, O_2 free KOH solution, (pH = 13)
O_2 sat. solution, Hg (pH = 13)

Polarity: — electrode, Fe-Hg; + electrode, Hg

Average current flow upon short circuiting cell:	5 times 10^{-5} amperes
Time of short circuiting:	180 minutes
Cathode electrolyte peroxide test:	Positive
	Temp.: 23° C.
Anode electrolyte peroxide test:	Negative

(b) With the same type cell but replacing the dilute KOH solution with a dilute H_2SO_4 solution (pH = 2.1) the same polarity and order of magnitude of currents were observed but no peroxide could be detected.

(c) With the same type cell but an approximately neutral solution of (K_2SO_4) the same polarity and order of magnitude of currents were observed but no peroxide could be detected. The cathode electrolyte in this case, as would be expected, gave an alkaline reaction with phenolphthalein indicating reduction of the oxygen to hydroxide ion.

In all of the above experiments oxygen was very slowly bubbled into the electrolyte above the mercury (cathode) surface in order to maintain an abundant supply of oxygen at this electrode. When a blank was run by bubbling oxygen for sixty minutes over the mercury surface, with the cell on open circuit, no peroxide could be detected in any case.

★ Submitted for publication August 29, 1949.

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** Here and in the following the term anode will be used to designate that point of surface at a metal-solution interface where the flow of negative charge is from solution to metal, while the term cathode will signify a flow of negative charge from metal to solution.

In making the peroxide test the titanium sulfate-sulfuric acid test[10] sensitive specifically to peroxide down to 5 times 10^{-5} molar was employed. When an attempt was made to measure the electromotive force of the above cells on open circuit it was found that the value was not constant and gave sudden and large fluctuations, although never reversing polarity. If the cell was shaken so as to disturb the electrode-electrolyte interface sudden shanges in potential were noted. Also it was observed, as expected, that the difference in potential between the two electrodes was generally greater when the Fe-Hg electrolyte was deoxygenated than when this was not the case.

These results parallel those obtained by Wieland and Franke, *loc. cit.*, when iron-amalgams are shaken with the various solutions mentioned. The fact that the peroxide could be produced over mercury alone in the cell described above shows that the amalgam shaking experiments may involve an action that is at least partially electrolytic in nature and may depend upon iron only for the generation of a favorable potential for the oxygen reduction, this latter process occurring perhaps only at the mercury-solution interface.

Experiments with Oxygen Reduction At an Iron Cathode

In their experiments Wieland and Franke obtained much smaller yields of peroxide when finely divided iron powder was shaken with their various solutions. The trend of peroxide yield ran parallel, however, to that obtained with the iron amalgams. This they explained as being in large part a consequence of the fact that any peroxide formed is immediately liable to further reduction or to reaction with the anode products.

The latter of these two factors can be removed by causing the anodic reaction to occur separately from the cathodic reaction so that no contact is allowed between the reaction products. The former might be removed or reduced by effecting a continuous flow of electrolyte past the cathode. This is, however, not generally the condition in ordinary corrosion, and in designing the apparatus described below it was thought advisable to study electrolytic reduction of oxygen only as it occurs at a still electrode-electrolyte interface as a function of current density and electrolyte composition.

An indication of the sensitivity required of a chemical test for peroxide at the concentrations at which it would exist as a corrosion product may be gained from the following considerations. If the iron cathode area were, for example, ten square centimeters, the cathode electrolyte volume, 40 cubic centimeters, and if a 100% yield of peroxide is assumed it can be calculated that with a current density of 1 times 10^{-6} amperes/cm^2 it would require more than ten hours to produce a 5 times 10^{-5} molar solution. This concentration of peroxide would be just detectable with the titanium sulfate reagent. During such an extended period, moreover, localized galvanic action could develop on the cathode and the ferrous and ferric ions thus formed would be very active in causing the decomposition of any peroxide present.

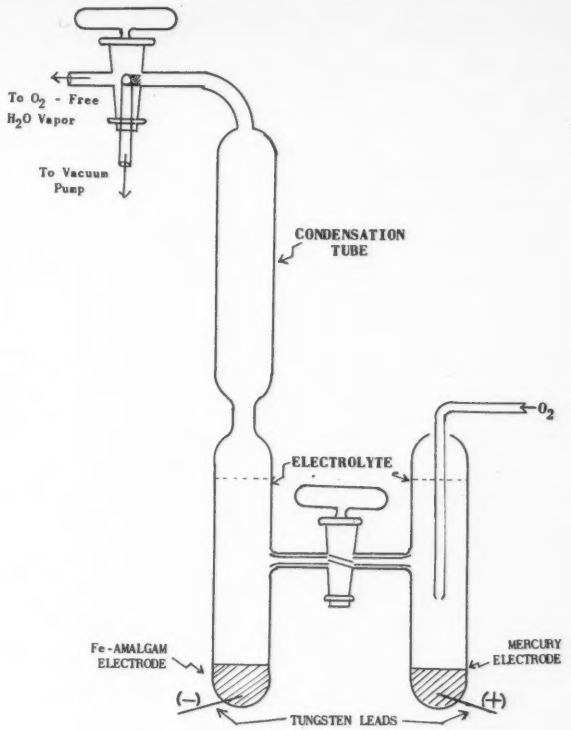

Figure 1—Fe-amalgam mercury cell.

On the other hand if much larger current densities than this are employed the conditions at the iron cathode would not duplicate those obtained in ordinary corrosion. Furthermore, at the higher potentials necessary to secure this greater current density any peroxide formed would be much more liable to further reduction.

A more sensitive method of peroxide analysis which allowed not only the detection but the quantitative determination of peroxide in concentrations as small as 10^{-6} molar was finally developed and used in these experiments. The method is described by the authors in a previous paper[11] and involved the catalyzed oxidation of iodide ion to iodine, with the peroxide solution to be determined, and the estimation of the free iodine by measurement of its light absorption with an ultra-violet spectrophotometer. In order to make the rather slow iodide ion-peroxide reaction go rapidly to completion use was made of the catalytic action of molybdic acid discovered by Brode[12] and employed by Kolthoff.[13] It was found that the maximum absorption was shown at 3500 A° and accordingly this wavelength was selected as the standard for all analyses performed. Some typical calibration data are shown in the table below:

TABLE I

Molarity of H_2O_2	I/I.	Log I/I.
Solution:		
13.1 times 10^{-6}	0.565	−0.248
6.35 times 10^{-6}	0.758	−0.120
3.17 times 10^{-6}	0.881	−0.055
1.31 times 10^{-6}	0.950	−0.022

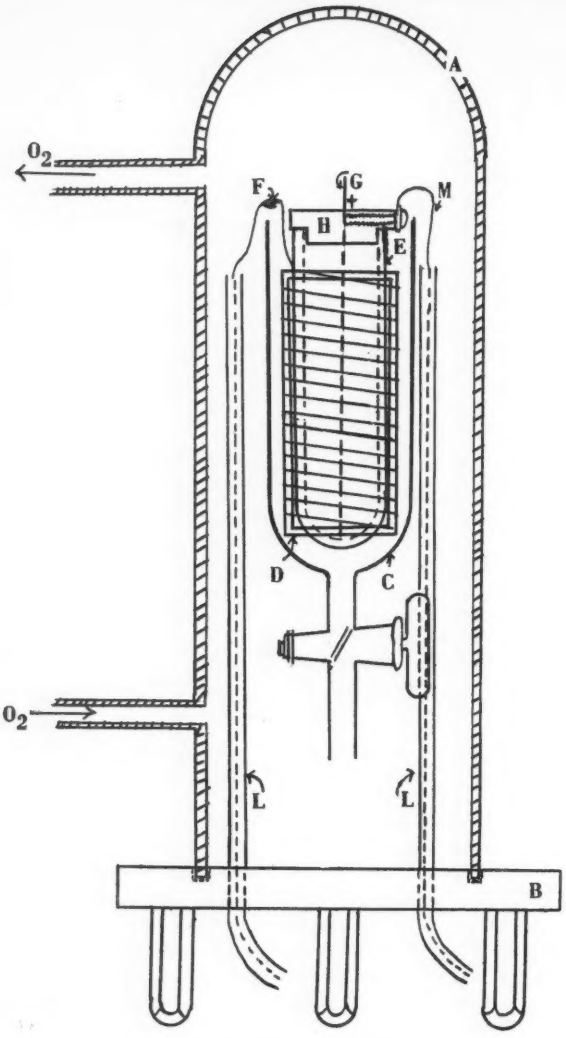

Figure 2—Iron cathode-oxygen cell.

Experiments with Iron Cathode

The apparatus depicted in Figure 2 was used in these experiments. The entire cell vessel, C, and contents, were enclosed in the glass cylinder, A, which fit snugly into a slot cut in the brass supporting base, B. Oxygen inlets and outlets to this otherwise closed cylinder were provided as shown so that by maintaining an atmosphere of pure oxygen above the electrolyte an abundant supply of oxygen to the electrode would be assured.

Inside the cell vessel, C, was supported a glass rod frame, D, square in cross section, about which the iron wire, F, was wound. Inside this glass frame was contained a porous alundum cylinder, E, closed at the bottom but open at the top. A brass cap, H, rested on top of this cylinder and through this cap passed a platinum wire, held in place by the screw shown.

In the experiments performed with this apparatus the iron wire served as cathode while the platinum wire constituted the anode. Connections of these electrodes to the outside were made through the two leads, L, which passed through snug fitting holes cut through the brass base.

In this way a fairly large area of cathode surface was obtained, and at the same time freer access of oxygen was assured than would have been the case if a plane surface rather than the wire had been used. At the same time the distance at all points between cathode and anode was maintained relatively constant by having the wire wound about the centrally located anode. The porous cup served the purpose of preventing mixing of the cathode and anode liquids.

The respective capacities of the cathode and anode compartments were thirty and eight cubic centimeters. The cathode electrolyte could be drawn off through the stopcock shown without disturbing the anode electrolyte.

The procedure in these experiments was as follows. The cell vessel, C, after being thoroughly cleaned and washed with distilled water was filled with about thirty cubic centimeters of the electrolyte to be employed. This was then saturated with oxygen by slowly bubbling into it a stream of oxygen for about one-half hour and then was placed under an atmosphere of oxygen inside the covering cylinder, A, of Figure 2, until used. Meanwhile a known length of known diameter iron wire, of the type made for analytical standardization, was wound around the glass frame, D. This was then immersed in acetone with slight agitation for about three minutes and then washed thoroughly with distilled water. The alundum cylinder, previously cleaned, was then quickly fitted into the glass frame and filled with about eight cubic centimeters of the electrolyte and the whole dropped into the glass cell, C. The platinum wire anode, held in H, was then placed atop the alundum cylinder and the leads connected. With these volumes of cathode and anode electrolyte the level of cathode liquid in C is made purposely slightly higher than the anode level in E so that the hydrostatic pressure thus developed would oppose any diffusion into the cathode electrolyte from the anode compartment. In all experiments a small cup of about the same capacity as the cell vessel, C, and containing the same length of iron wire, treated in the same way, was placed inside the apparatus on the stand, B, and allowed to remain inside during the experiment. This was for the purpose of determining whether there was any blank to be corrected for in the cathode analysis due to any interfering substance in the oxygen gas, or iron, present as the result of ordinary corrosion occuring during the course of the experiment. A dry cell served as the source of cur-

TABLE II

Electrolyte: Dilute H_2SO_4, pH = 4.25

Cell temperature: 21 deg. C. **Cathode area: 8.64 cm^2**
Cathode electrolyte volume: 30 cc. **Time of run: 180 minutes**

Current Density (amps./cm^2)	Percent Absorption	Percent Yield H_2O_2
$5.84 \cdot 10^{-7}$	0.0	0.0
$2.46 \cdot 10^{-6}$	0.0	0.0
$4.47 \cdot 10^{-6}$	0.0	0.0
$6.41 \cdot 10^{-6}$	0.0	0.0

rent, the current being measured on a calibrated wall-type galvanometer.

A series of experiments using various electrolytes at different pH values was made. Some typical data and results calculated therefrom are tabulated in Tables II, III and IV.

An illustration of the method used in calculating peroxide yield is given here:

(a) Cathode surface area:
$(120 \text{ cm.})\ (3.14)\ (.022) = 8.29 \text{ cm}^2$

(b) Current density: $\dfrac{(4.35 \text{ amps})\ (10^{-5})}{8.29 \text{ cm}^2}$
$= 5.25 \text{ times } \dfrac{10^{-6} \text{ amps}}{\text{cm}^2}$

(c) Percent transmission upon analysis:
$100 - 18.3 = 81.7\%$

(d) $I/I_o = \dfrac{81.7}{100} = 0.817 \quad \text{Log } I/I_o = -.0878$

(e) H_2O_2 molarity of cathode electrolyte after run:
5.4 times 10^{-6} (from standardization data)

(f) H_2O_2 moles produced: $(5.4)\ (10^{-6}) \dfrac{(30)}{(1000)}$
$= 16.2 \text{ times } 10^{-8}$

(g) Theoretical moles H_2O_2: $\dfrac{(4.35)\ (10^{-5})\ (120)\ (60)}{(2)\ (96{,}500)}$
(100% current effic.)
$= 16.20 \text{ times } 10^{-7}$

(h) Percent of theoretical yield: $\dfrac{(16.2)\ (10^{-8})\ (100)}{(16.2)\ (10^{-7})}$
$= 10.0\%$

In connection with the peroxide analysis ferric ion was considered as a possible interfering material. With certain relatively low current densities, as for example with current densities less than 10^{-6} amperes/cm^2 with the neutral electrolyte, it was found that there was a tendency for some iron to pass into solution. In all experiments, however, a blank was run by taking an aliquot portion from the cathode electrolyte after electrolysis and allowing this to evaporate completely in a vacuum dessicator. The portion of solution taken for this purpose was always made slightly acid before evaporation to insure that any peroxide present would be completely in the form of the molecular peroxide. The completely dry residue was then redissolved in distilled water, reagents added, and a reading taken on the spectrophotometer. In most cases no absorption was detected. If in any case the absorption obtained with the blank run in this way amounted to more than 10 percent of the reading for the original cathode solution the run was discarded. With all the runs made the other blank (see page 9) gave no iron present. This was determined by the same analytical procedure.

TABLE III

Electrolyte: Na_2SO_4, pH = 6.5

Cell temperature: 21 deg. C. Cathode area: 8.29 cm^2
Cathode electrolyte volume: 30 cc. Time of run: 120 minutes

Current Density	Percent Abs.	Log of I/Io	Molarity	Moles Produced	Theo. Moles	Percent Yield
$8.00 \cdot 10^{-7}$	5.2	—0.0232	$1.2 \cdot 10^{-6}$	$3.6 \cdot 10^{-8}$	$2.47 \cdot 10^{-7}$	14.2
$2.04 \cdot 10^{-6}$	11.0	—0.0506	$2.9 \cdot 10^{-6}$	$8.7 \cdot 10^{-8}$	$6.30 \cdot 10^{-7}$	13.8
$5.25 \cdot 10^{-6}$	18.3	—0.0878	$5.4 \cdot 10^{-6}$	$16.2 \cdot 10^{-8}$	$16.20 \cdot 10^{-7}$	10.0
$6.50 \cdot 10^{-6}$	13.7	—0.0640	$3.8 \cdot 10^{-6}$	$11.4 \cdot 10^{-8}$	$20.1 \cdot 10^{-7}$	5.7

TABLE IV

Electrolyte: Dilute NaOH solution, pH = 11.1

Cell temperature: 21 deg. C. Cathode area: 8.64 cm^2
Cathode electrolyte volume: 30 cc. Time of run: 180 minutes

Current Density	Percent Abs.	Log of I/Io	Molarity	Moles Produced	Theo. Moles	Percent Yield
$4.84 \cdot 10^{-7}$	10.5	—0.048	$2.8 \cdot 10^{-6}$	$8.45 \cdot 10^{-8}$	$2.34 \cdot 10^{-7}$	36.1
$7.43 \cdot 10^{-7}$	9.2	—0.042	$2.4 \cdot 10^{-6}$	$7.30 \cdot 10^{-8}$	$3.60 \cdot 10^{-7}$	20.3
$1.05 \cdot 10^{-6}$	4.1	—0.018	$0.9 \cdot 10^{-7}$	$2.68 \cdot 10^{-8}$	$5.07 \cdot 10^{-7}$	5.3

Summary and Discussion of Results

As seen by inspection of the preceding tables the greatest yields of peroxide were obtained with the alkaline solutions and small current densities. The fact that in these experiments, as well as in those of Wieland and Franke, peroxide formation was observed to occur in alkaline solution, would seem to indicate that hydrogen ion, as such, need not be involved necessarily in the mechanism whereby oxygen is reduced to peroxide. It is at the same time quite possible that hydrogen peroxide is also formed in the acid solutions but is here more quickly reduced further to hydroxide ion, and this of course reacts to form water.

A possible explanation of the instability of hydrogen peroxide at the cathode in acid, as in contrast to alkaline solution, may lie in the fact that in the former case the peroxide would exist almost entirely in molecular form, whereas in the latter case the peroxide would exist largely in the form of peroxyl ion. This negatively charged ion would be expected to migrate from the cathode, preventing further reduction, a situation that would not develop in the case of the neutral peroxide molecule. This picture is in agreement with the polarographic observations of Kolthoff and Miller[14] who found two distinct reduction potentials for oxygen in solution, between pH values 1 and 10, the first corresponding to reduction to peroxide, the second to hydroxide ion. At higher pH values two reduction steps were not observed. Using the polarograph Van Rysselberghe et al[15] obtained a two step reduction of oxygen, the first near 0.1 volt to form hydrogen peroxide and the second near 1 volt to form water.

These results indicate hydrogen peroxide as the intermediate formed in oxygen reduction at an iron cathode. It would seem, therefore, that in any oxygen-ferrous corrosion process, where an electrochemical mechanism is involved, hydrogen peroxide rather than hydroxide ion should be considered as the primary cathodic reaction product.

If hydrogen peroxide is the primary product of reaction at the cathode the potential of the corrosion cell (i.e., the "driving force" for the process) will be different than if this is hydroxide ion. It is also quite possible that, instead of in all instances being further reduced electrolytically to hydroxide ion, the hydrogen peroxide initially formed would react further with ferrous ion, the latter having formed at proximate anodic centers.

Certainly other important implications of the peroxide intermediate can be postulated, and the further

investigation of these should throw additional light on the nature of the corrosion process.

References

1. G. N. Lewis, *J. Amer. Chem. Soc.*, **28,** 158 (1906).
2. M. Traube, *Ber. Deutsch. Chem. Ges.*, **XV,** 659, 2434 (1882).
3. Richarz and Lonnes, *Zeitsch. Phys. Chem.* **20,** 145 (1896).
4. Fischer and Priess, *Ber. Deutsch. Chem. Ges.*, **46,** 698 (1913).
5. Riesenfeld and Solowjan, *Zeitsch. Phys. Chem.*, Bodenstein Festband, 405 (1931).
6. Furman and Murray, Jr., *J. Amer. Chem. Soc.*, **58,** 429 (1936).
7. Weiss, *Trans. Faraday Soc.*, **31,** 1547 (1935).
8. Wieland and Franke, *Annalen der Chemie*, **469,** 257 (1929).
9. Patrick and Wagner, *J. Anal. Chem.*, **21,** 752 (1949).
10. D. M. Yost, and H. Russell, Jr., "Systematic Inorganic Chemistry," Prentice Hall, N. Y. (1944).
11. Patrick and Wagner, *J. Anal. Chem.*, **21,** 1279 (1949).
12. Brode, *Zeitsch. Phys. Chem.*, **37,** 257 (1901).
13. I. M. Kolthoff, *Zeitsch. Anal. Chem.*, **60,** 400 (1921).
14. I. M. Kolthoff and C. S. Miller, *J. Amer. Chem. Soc.*, **62,** 2171 (1940).
15. Van Rysselberghe, et al, *Corrosion and Material Protection*, **5,** No. 2, 11-16 (1948) Mar.-Apr.; *Ind. Eng. Chem.*, **40,** 16a, 22A (1948) Apr.

You Are Invited to Submit

QUESTIONS or ANSWERS

to

"CORROSION PROBLEMS"

See Page 8 in the News Section This Issue

The National Association of Corrosion Engineers will print requests for information leading to the solution of problems in the mitigation of corrosion. Solutions to published problems are solicited.

It is suggested that persons seeking information about a corrosion problem give sufficient information to make a comprehensive answer possible. If graphs, tables or photographs are essential to such an explanation they are welcomed.

ADDRESS QUESTIONS OR SOLUTIONS

TO

NATIONAL ASSOCIATION OF CORROSION ENGINEERS

919 MILAM BUILDING, HOUSTON 2, TEXAS

Attention: N. E. HAMNER, *Managing Editor*

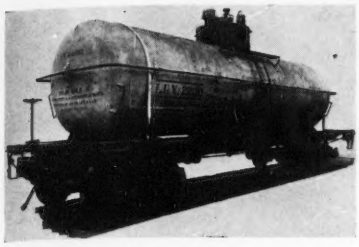

Figure 1—A 10,000-gallon aluminum alloy tank on a car for transportation of ammonium nitrate solutions. (Photo courtesy General American Transportation Co.)

Topic of the Month

Aluminum Alloys for the Storage And Transportation of Chemicals

By E. D. VERINK, JR.*

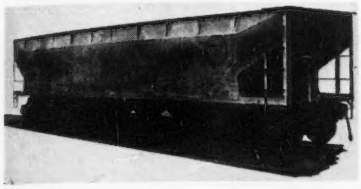

Figure 2—A hopper car for transportation of sulfur constructed of aluminum alloys to combat corrosion encountered in this difficult service. (Photo courtesy Missouri Pacific Lines)

MATERIALS FROM which much equipment for the storage and transportation of chemicals is fabricated are required to possess an unusual combination of properties. In addition to resistance to corrosion, it may be necessary that they posses non-sparking characteristics, and chemical properties which are not harmful to the product from the viewpoint of discoloration, contamination, and catalytic decomposition. In many cases the materials and their compounds must be non-toxic. In the transportation field weight is often of the utmost importance. The fabricator of such equipment requires that the alloy employed for the fabrication be easy to form, machine and join. To a remarkable degree, aluminum alloys fulfill the requirements of both the fabricator and the user with economics over older materials and methods.

Aluminum alloys are used for the fabrication of items ranging in size from shipping drums for the transportation of many chemicals such as nitric acid and hydrogen peroxide to large storage tanks for formaldehyde having a storage capacity of over 311,000 gallons. An instance in which color of the product was one of the primary considerations is illustrated in Figure 3 which is a photograph of a series of aluminum tanks for handling water-white vegetable oils and fatty acids. Figure 4 is a large tank of a different type of construction used for the storage of an organic chemical.

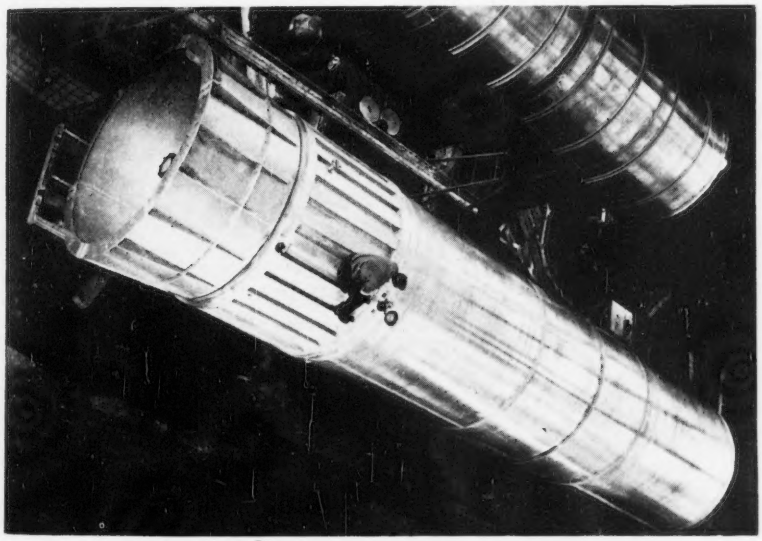

Figure 4—Another large tank used for storage of an organic chemical.

Another example where the light weight of aluminum alloys, in addition to its many other valuable properties, afforded an economical solution to a difficult transportation problem is shown on the cover of this issue. This is a barge in which are mounted nine aluminum alloy tanks each of which is ten feet in diameter by 46 feet long used in the transportation of acetic anhydride over the inland waterways system. Because the displacement of such barges is controlled by draft limitations, the useful load can be increased because of reduction in weight resulting from use of aluminum alloy tanks. The resistance to corrosion of aluminum alloys has played a large role in reducing transportation costs of many chemicals in tank cars. The aluminum tank car fleet on American Railroads in now numbered in the hundreds. A partial list of chemicals handled includes acetic acid, acetic anhydride, nitric acid, hydrogen peroxide, Sorbitol, glycerine, trichlorobenzene, ethyl acetate and formaldehyde. Figure 1 is an example of a 10,000-gallon tank car for the transportation of ammonium nitrate solutions. An even greater list of chemicals now shipped in aluminum containers could be enumerated. Aluminum alloys also are used for LCL and carload shipment of chemicals in the solid and semi-solid condition. The corrosion problem encountered in the shipment of sulfur in hopper cars was solved by the use of aluminum cars such as the type shown in Figure 2.

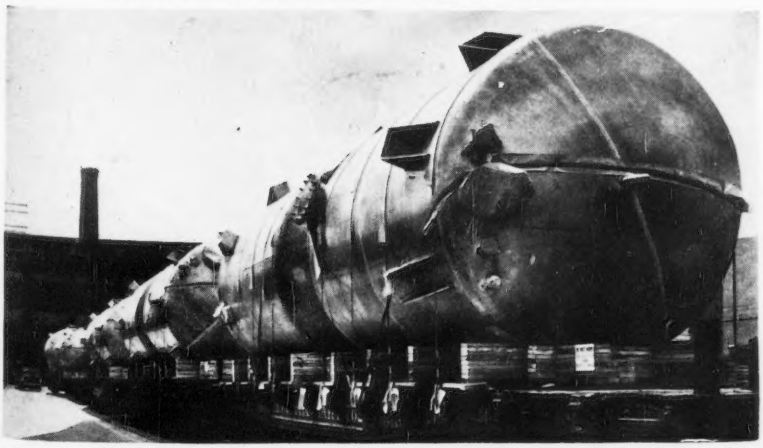

Figure 3—A group of large aluminum tanks for handling water-white vegetable oils and fatty acids.

* Aluminum Company of America, New Kensington, Pa.

NACE News

Petition is Filed for Section in Los Angeles

Joint Meeting of Baltimore Section and North East Region Has Attendance of 117

North East Region's joint meeting with Baltimore Section at Hotel Stafford, Baltimore was attended by 117 from ten states. NACE officials present included three national directors, Messrs. P. W. Bachman, L. J. Gorman and R. H. Lynch; two regional officials, Mssrs. N. P. Peifer and L. B. Donovan and H. L. Hamilton, chairman of Philadelphia Section and T. P. May, chairman Metropolitan New York Section. National President R. B. Mears was unable to attend.

The technical program was a symposium of four papers on tide water corrosion. F. L. LaQue of International Nickel Co., Inc., New York, described extensive testing facilities at Kure Beach, North Carolina, where 25,000 specimens are under examination in his presentation titled "Practical Application of Kure Beach Exposure Tests to Salt Water Corrosion Problems." Among numerous examples of findings Mr. LaQue's description of investigations on the corrosive action of sea water on steel pilings was notable. He stated it was surprising to find comparatively mild attack in the tidal zone, with greatest corrosion immediately above and a lesser peak just below. Responsibility for this was attributed to oxygen concentration cell effects with the spray zone most active as an anodic corroding area affording some measure of protection to other zones of the piling.

J. K. Knoerle, of J. E. Greiner Co., Consulting Engineers, Baltimore, who spoke on "Present Practices and Experiences with the Use of Steel Piles in Waterfront Structures Along the Atlantic Seaboard," told of several interesting experiences with steel pilings along the Atlantic Seaboard, inserting humorous illustrations of piling material specifications which served to point out how badly additional factual information on corrosion resistance is needed.

J. L. Basil, of U. S. Naval Experiment Station, Annapolis, delivering the paper "Corrosion Tests of Condenser Tube Alloys in Sea Water and Severn River Water," prepared by him and W. G. Schreitz of the same station, described tests, principally with red brass and cupro-nickel alloys in sea water at Kure Beach and in Severn River water. Great importance of water velocity in corrosion testing is being emphasized in this work, he said. Critical velocities are being obtained for various systems through the use of spinning metal discs on which the radius beyond which corrosion occurs may be observed.

Corrosion
News Deadline:
10th of Month
PRECEDING
Date of Issue

F. M. Reinhart, of the Department of Metallurgy, National Bureau of Standards, Washington, D. C., described seawater immersion tests with various combinations of aluminum and magnesium aircraft alloys in contact with stainless steel. The bimetallic specimens were joined with anodized aluminum alloy rivets. The great importance of relative surface areas (cathodic and anodic areas) as a controlling factor in determining the rate of metal attack was brought out clearly.

New Officers Named for Metropolitan N. Y. Section

New officers of the Metropolitan New York Section have been named as follows: T. P. May, International Nickel Co., Inc., 67 Wall Street, New York; H. W. Wahlquist, Ebasco Services, Inc., 2 Rector Street, New York; and F. J. LeFebvre, Electro Rust-Proofing Corp. (N. J.), 1 Main Street, Belleville, N. J.

Kenneth Tator of Kenneth Tator Associates, Coraopolis, Pa., spoke on "Organic Linings in the Chemical Industries at the November 9 meeting of Metropolitan Section. His talk covered materials, surface preparations, applications and testing.

Sixty-eight members and guests were present.

W. Z. Friend, International Nickel Co., Inc., N. Y., will speak February 8 on "Developments in the Use of Metals and Alloys in the Chemical and Process Industries," at the Building Trades Employers' Association, 2 Park Ave., N. Y. Mr. Friend has been in the corrosion engineering section of the development and research department of his company since 1937. Good attendance is expected.

Formation of a Los Angeles section to take over the section activities for that locality which have been concurrent with the functions of the Western Region will be completed soon. Western Region, at a dinner meeting November 30 at Robert Young Auditorium, Los Angeles attended by 90 members and guests voted to ask for an application for a new section. David T. Jones, newly elected regional chairman will act as temporary chairman.

Officers elected for 1950 were David T. Jones, The Pacific Telephone and Telegraph Co., North Hollywood, Cal., chairman; L. L. Whiteneck, Long Beach Harbor Department, Long Beach, Cal., vice-president and W. M. Schilling, Southern Counties Gas Co., Bell, Cal., secretary-treasurer.

It was reported that a Pacific Coast branch of Technical Practices Committee No. 1—Corrosion of Oil and Gas Well Equipment, was in process of formation.

Eighty attended the dinner and about ten more came in later.

The technical program consisted of "A Corrosion Study of Causes Contributing to a Cast Iron Bolt Failure for the Sorrento Pipeline," by E. C. Rogness, city of San Diego; "Combating Corrosion in the Long Beach Water System," by C. Kenyon Wells, City of Long Beach Water Department and "Corrosion Problems of the Bureau of Water Works and Supply," by Robert R. Ashline, Los Angeles Department of Water and Power.

A discussion of water system corrosion problems followed the prepared papers.

Non-Destructive Testing San Francisco Bay Topic

Non-destructive Testing in Petroleum refineries was the scheduled subject of a talk by Glenn Vergne of Tide Water Associated Oil Co., Avon California Refinery at San Francisco Bay Area Section dinner meeting December 13. Also scheduled for showing was a color film on the Trans-Arabian Pipe line. An election of section officers also was planned.

Forty-two were present for the October 11 meeting at El Curtola Restaurant, Oakland when W. G. Collins of Pacific Telephone and Telegraph Co. spoke on the corrosion of lead-sheathed cable. He covered manufacture and history, types of corrosion encountered, methods of identifying various types of corrosion, tests and value of tests, and mitigation measures.

South East Region's Fall Meeting Held in Birmingham

Technical sessions during the afternoon and evening and nomination of officers for the coming year were principal items on the agenda of the Fall meeting of the South East Region at Birmingham, Ala. November 15. Officers nominated for the coming year were: J. W. Yeldell, Southern Natural Gas Co., chairman; E. P. Tait, Aloyco Steel Co., vice-chairman; and J. F. Johnston, American Telephone and Telegraph Co., secretary-treasurer.

The 1950 Spring meeting date was tentatively set for March 14 in Atlanta.

Afternoon Session

The afternoon program consisted of one session on protective coatings led by R. P. Devoluy, C. A. Woolsey Paint & Color Co., Inc., and another on stray current corrosion led by E. B. Mitchell, Shell Pipe Line Corp. At the evening session E. D. Verink, Aluminum Company of America, discussed the use of aluminum in the chemical industry.

Mr. Devoluy presented an analysis of coating failures under the topic of types of failures and their causes, methods of surface preparation and application.

Under the general type of failure he discussed loss of film strength, excessive chalking, general blistering and checking and cracking. Surface preparation procedures such as sand blasting, chipping, mechanical cleaners, vacublast, paint removers, as well as removal of any oil coatings were analyzed.

In considering application of coatings the importance of using different colors for multicoat jobs he emphasized. Because thinner coats usually are obtained in inaccessible locations and on edges it is well to specify more coats to get the necessary thickness of the total coating. Dr. Devoluy said if specifications required a definite thicknesses rather than a number of coats, more uniform coating jobs would be obtained. The importance of proper equipment, trained applicators and trained inspectors was emphasized.

In a brief discussion of primers, red lead and zinc chromate were believed to be of equal value. The advantages of the so-called wash primers, which are applied before red lead or zinc chromate were brought out by inspection of test panels. The wash primers are an alcohol solution of resin and phosphoric acid. This material dries quickly and makes an excellent foundation for the regular primer and protective coating. Some of the properties of the vinyl paints, such as alkali and electrical resistance, were explained.

Mr. Devoluy closed his remarks by saying the coating system should be designed at the time the structure is designed.

Stray Current Problems

Mr. Mitchell's presentation of a procedure for analyzing and solving stray current problems was in the following steps:

1. Location of electric railway power station and substation.
2. Location of trunk system with respect to structure under consideration.
3. Hours of operation of electric railway.
4. Direction and amount of current flow on structure.
5. Location of adjacent underground structures.

Methods for determining the direction and amount of current flow on the structures were diagrammed and described. Along with the survey of the underground structure the need for surveying the railway to learn type of connections between rails, condition of beds and voltage radiant of rail was explained.

The following methods of controlling stray currents were discussed:

1. Improvements in railway system.
2. Breaking up circuit path by insulation.
3. Forced drainage.
4. Making positive bond between structure and negative bus.

Aluminum for Construction

Mr. Verink asserted aluminum is an important construction material for services where corrosion resistance is necessary because of the following properties:

1. Formability.
2. Non-toxicity, with such corrosion product as is formed of such a nature as not to affect the color of the product.
3. Low specific gravity.
4. Non-sparking characteristics.
5. Strength in alloy form.
6. Good electrical and thermal conductivity.
7. Non-magnetic characteristics.
8. Reflective characteristics.
9. Availability in a variety of finishes.

Slides were shown showing corrosion rate curves and structural shapes now in use in a variety of industries. Of special interest was the all-aluminum oxygen manufacturing plant at McCarthy Chemical plant, Winnie, Texas and the large variety of chemical storage and transport vessels constructed of aluminum.

The functions of Alclad surfaces were detailed. Curves demonstrating agreement between exposure tests and actual life of equipment in atmosphere were interesting and informative.

The discussion also included data on the development of aluminum anodes and soil pipe. Mr. Verink confined his discussion to alloys with low copper content.

Philadelphia Section Holds Meeting December 12

Officers were elected for 1950 by the Philadelphia Section at a dinner meeting December 12 at the Engineers' Club, Philadelphia. Fifty-six members and guests were present for the dinner. The new officers are: Robert R. Pierce, Pennsylvania Salt Manufacturing Co., chairman; H. F. McConomy, Atlantic Refining Co., vice-chairman and Ernest H. Wyche, Lukens Steel Co., secretary-treasurer.

The names of the officers had been placed in nomination by the nomination committee and when there were no nominations from the floor, the secretary was instructed to record an unanimous vote for the officers.

Seventy-six were present for an informal discussion on the following topics: Natural and Synthetic Rubber in Handling Corrosives, Application of Aluminum Heat Exchanger Tubes to Corrosive Services and "Teflon" Polytetrafluorethylene finishes.

Salt Lake Section to Nominate New Officers

"High Temperature Oxidation of Manganese and Magnesium Alloys" is the scheduled topic of discussion for the December 14 meeting of Salt Lake City Section at the auditorium of the Utah Power & Light Co. Also scheduled to be considered at this meeting is the draft copy of the by-laws and regulations for the section, which held its organization meeting October 27 at the Newhouse Hotel.

At the organization meeting Dr. George Hill of the University of Utah presented a paper on the subject "Underwater Corrosion of Copper." Harry R. Brough, temporary officer named at this meeting reported officers for the year will be nominated at the January meeting, to take office at the first meeting in February.

CORROSION magazine seeks for publication notices of meetings of associations other than NACE which conduct corrosion investigations and research work. Members who know of such activities not reported in CORROSION are asked to notify Central Office so steps may be taken to publish the information.

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Greater St. Louis Section Hears M. A. Scheil At Dinner Meeting Attended by Eighty

M. A. Scheil of A. O. Smith Corp. spoke to some 25 members and 55 guests at the November 21 meeting of Greater St. Louis Section at a dinner meeting held in Garavelli's Victoria Tea Room. Mr. Scheil's Topic was "Effects of Carbon, Columbium and Molybdenum on the 18-8 Austentitic Stainless Steels."

Mr. Scheil's presentation was the initial release of recently developed data on the effect of alloying elements on the corrosion resistance of the more frequently used stainless steels.

Wm. F. Gross, secretary of the section, reported this to be the largest meeting held by the section, with nearly 80 present and high interest shown in the paper and the association.

In place of L. G. Vande Bogart, who is ill and unable to present the program as scheduled December 19, George McComb of Standard Pipeprotection, Inc., will discuss protective coatings and their application and show a color motion picture on construction of the "Big Inch" pipe line.

Chicago Section Schedules Address by R. B. Mears

R. B. Mears, of Carnegie-Illinois Steel Co., Pittsburgh, Pa., president of NACE will address the Chicago Section January 4 on "Passivity and Inhibition."

Chairman J. Pat Casey, Jr., also reported a joint meeting was held with the Electrochemical Society December 2 at which Robert Flournoy of Corn Products Refining Company spoke on "Corrosion Tests and Experience in Corn Refining."

Houston Holds Second Cathodic Protection Panel

Practical aspects of cathodic protection was the subject of a panel-type program at the December 13 meeting of Houston Section. E. P. Doremus of Cathodic Protection Service, Houston moderated the discussion. This program was the second of two on cathodic protection, the first, directed by Lyle Shappard of Shell Pipe Line Corp., having to do with theoretical aspects.

Mr. Doremus outlined briefly the history and fundamentals of cathodic protection, touched on the economics of rectifiers plus ground beds vs anodes and defined requirements of each system. Design factors were discussed, especially the economics of less than 100 percent

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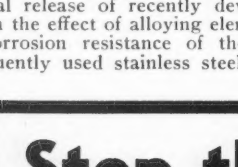
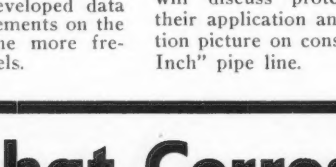
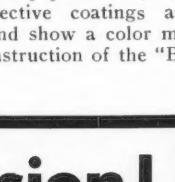

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protection and the comparative values of "hot spot" and overall protection.

E. B. Mitchell of Shell Pipe Line Corp., next speaker devoted his remarks to installation and maintenance problems. Types of equipment, typical difficulties encountered, the necessity for continuous maintenance and systematic inspection were explained. Mr. Mitchell pointed to the clogging of air-cooled rectifiers, breakage of lead wires, backfill shrinkage, shorting of insulating flanges and sealing off of anodes as a few examples of maintenance problems. Education was credited with an important place in the maintenance program. Pipe line crews also should be educated in the need and function of the systems and notified of all equipment dispositions.

Oliver Osborn of Dow Chemical Co., Freeport, concluded the panel remarks with a discussion of problems in process equipment handling at the Dow plant. Types of anodes available and typical uses at the Dow plant were given, illustrated with colored slides.

Highly corrosive conditions in flumes, filters and tanks were combated with magnesium anodes. Cost of the protection program was given as well as estimates on the cost of replacing equipment. Instances of substantial savings from the installation of anodes were given.

A new protection for barges was illustrated. This involves bolting anodes directly to the hull below the water line at about two-foot intervals. No conclusions are available as to the value of the installation because it still is in the experimental stage.

More Titles of 1950 Conference Papers Are Listed for Two Symposia by Chairmen

A new title and two revised titles of papers to be presented during the 1950 NACE Conference in St. Louis April 4-7 have been given by Robert J. Kuhn, chairman of the Cathodic Protection Symposium as follows:

New paper not reported before: "A Study of Metals for Use as Permanent Anodes in Water Tank Cathodic Protection Systems," by A. L. Kimmel, Assistant Professor, College of Engineering, Department of Chemical Engineeering, University of Florida, Gainesville, Fla.

Revised titles for two papers: "Cathodic Protection of an Active Ship in Sea Water," by G. L. Christie, Naval Research Establishment, H.M.C.S. "Stadacona" Halifax, Nova Scotia. "The Performance of Magnesium Anodes Under Service Conditions," by H. A. Robinson, Assistant Director Laboratory, Development Division, Magnesium Laboratories, The Dow Chemical Co., Midland, Mich.

Food Industries Symposium

Following is a list of papers tentatively scheduled for the Food Industries Symposium during the 1950 Conference as given by Curtis E. Maier, chairman:

"Corrosion Resistant Equipment for the Corn Refining Industry," by R. W. Flournoy, Engineer, Corn Products Refining Co., Development Engineering Dept., Argo, Ill.

"Metals Used in the Dairy Industry," by C. Y. McGown, Assistant to Vice-President, The Creamery Package Manufacturing Co., Chicago, Ill.

"Some Aspects of the Corrosion of Tin Plate by Prunes," by V. W. Vaurio, Research Chemist, Carnegie-Illinois Steel Corp., Pittsburgh, Pa.

●

Nine booths remain unallocated as of December 14 in the exhibit space at the Jefferson Hotel, St. Louis, where the 1950 NACE Conference and Exhibition will be held April 4-7. Fifty-two companies have reserved 68 booths.

All 1950 Conference exhibitors have been asked to submit a news story about their displays for publication in the pre-conference (March) issue of CORROSION. Informative articles about the exhibits are expected to be a factor in increasing interest and attendance at the conference.

The following list of exhibitors is additive to the two published in the November and December, 1949 issues:

The International Nickel Co., Inc., New York, N. Y.

Minnesota Mining & Manufacturing Co., St. Paul, Minn.

The Natasco Co., Tulsa, Okla.

The National Lead Co. (Metals Division), New York, N. Y.

Pipeline Maintenance Corp., Tulsa, Okla.

The Ruberoid Co., New York, N. Y.

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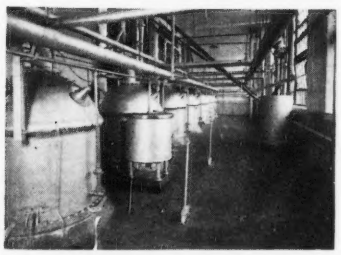

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Protective Coatings Is Tulsa Section's Topic

Tulsa Section heard Jack P. Barrett, Stanolind Oil and Gas Co., Tulsa, Okla., speak on "Painting and Corrosion Problems in Gasoline Plant Operations," Monday, December 12, at its regular monthly meeting. The section is making plans for a short course on corrosion to be held during February, probably on three consecutive days. Full information on the proposed short course is scheduled to be published in the February issue of CORROSION.

Mr. Barrett gave a summary of the principal means whereby corrosion is prevented, mentioning alloys, chemical inhibitors, electrical systems and protective coatings.

Coating Systems Outlined

Coatings are divided into two classes, metallic and organic and the purpose of both is to interpose a barrier between the metal and its environment, he said.

Organic coatings of several types are available, with growing interest and use forecast for plastic and bitumens, which are used most for corrosion prevention.

Principal consideration in the choice of a coating, Mr. Barrett said, is the exposure condition. Basic properties of resins to be used also should be considered. Other considerations of importance include type and size of equipment to be protected; (If the installation is small enough it may be protected by a baked-on or lining-sheet application.) environment and temperatures.

Laboratory Testing

Mr. Barrett also outlined principal laboratory tests for coatings. These included moisture vapor transmission, adhesion, abrasion, flexibility, resistance to chemical agents, salt fog test, H_2S exposure.

The value of laboratory testing is in determining the properties of a system and not in duplicating exactly field conditions, he said.

The physical application of a coating is to a large extent the major factor in the success of the job, he believes.

Next meeting of the section has been scheduled for the fourth Monday in January, the 23rd.

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Corpus Christi Section scheduled a talk by B. F. Heye, Efficiency and Results Engineer, C. P. & L. Co., on "Treating Cooling Tower Waters to Combat Corrosion," at its November 30 meeting at the Princess Louise Hotel.

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North East Region's board of trustees announced the following agenda for a meeting December 6 at Hotel Stafford, Baltimore: Results of election of regional officers; proposals for stimulating section activity in New England-Boston area; proposals for stimulating activity in Western N. Y.-Buffalo area; report on Dallas Regional Management Committee meeting in Dallas, Oct. 2; report from section trustees designating section officers for calendar year, 1950; financial reports from section chairmen and proposed plans for North East activities, 1950.

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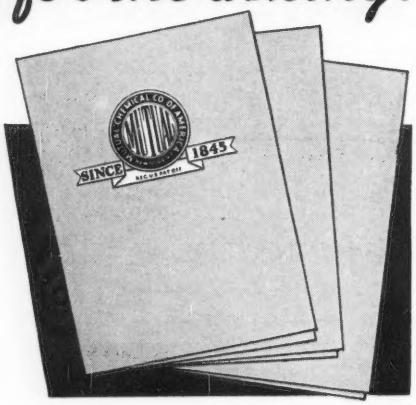

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- ☐ Serial No. 55—"Corrosion Inhibition with Chromate in the Oil and Gas Industries."
- ☐ Serial No. 56—"Some Properties of Technically Important Hexavalant Chromium Compounds."

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NACE CALENDAR

METROPOLITAN N. Y. SECTION—February 8, Building Trades Employers' Association, 2 Park Ave., N. Y. "Developments in the Use of Metals and Alloys in the Process Industries," by W. Z. Friend, International Nickel Co., Inc.

GREATER ST. LOUIS SECTION—Next meeting January 16. Scheduled program "Some Aspects of the Design and Fabrication of Equipment for Corrosive Service," by F. W. Davis, Chief Metallurgist, E. B. Badger & Sons, Boston, Mass.

CLEVELAND SECTION — February meeting scheduled program "The Effect of Composition of Steels on Corrosion," by C. P. Larrabee, Carnegie-Illinois Steel Corp.

SHREVEPORT SECTION — Regular meeting day is second Thursday monthly.

TULSA SECTION—Next meeting is January 23.

HOUSTON SECTION — January 10. "Vinyl Coatings," Mr. Pitzer.

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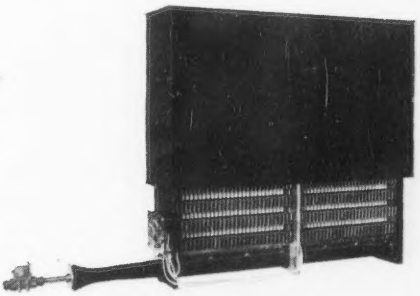

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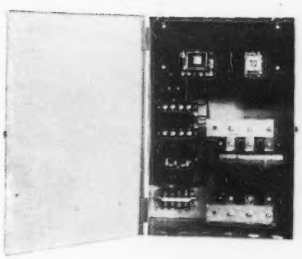

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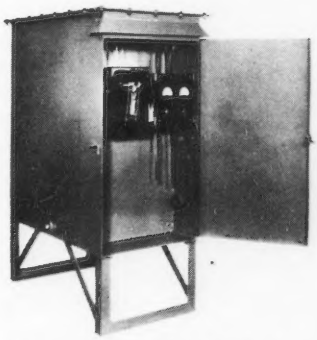

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Substantial Gains Made In Material Published

Substantial gains have been made in the quantity of technical material published in CORROSION magazine in 1949 over 1948 and in the number of authors supplying such material. A portion of the area increase resulting from the changeover from 6 x 9-inch size to the 8¼ x 11¼-inch size, can be attributed to mechanical considerations resulting from the wider column size. A quantitative comparison of the technical material in Volume IV with that in Volume V follows:

Total Pages Published

About 450 pages of technical material was published during 1949. Each of these pages is almost exactly twice the area of those published in 1948. Translating this into pages of size equivalent to those in 1948: Published in 1949—900 pages. Published in 1948—625 pages. Increase—44 percent.

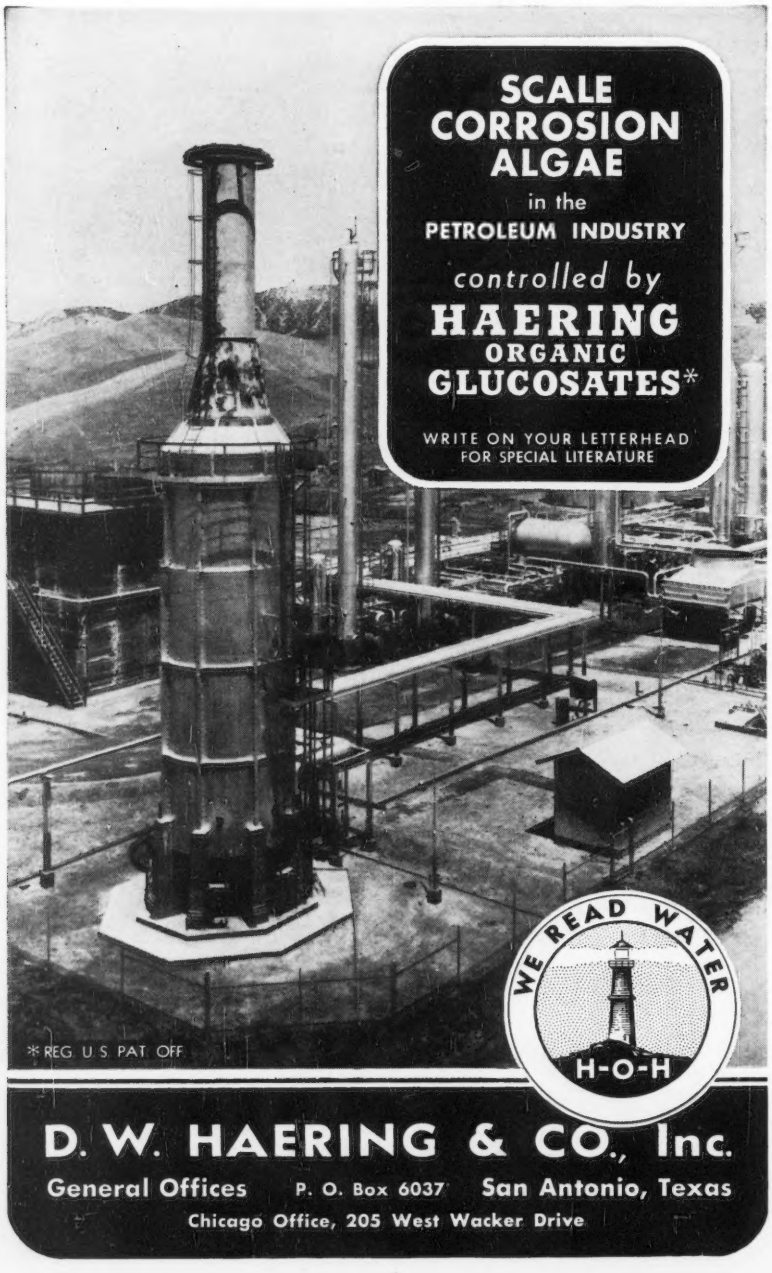
Total Titles Published

During 1949 72 titles were listed. (Of this number three were by anonymous authors and 11 were "Topic of the Month" features.) Published in 1948—49 titles. Increase—46 percent.

Total Authors Represented

During 1949 117 authors are named and three articles were by anonymous authors, making a total of 120. During 1948 there were indexed 62 authors. Increase—93 percent.

These lists of titles do not include features such as "Technical Committee Activities" or "Technical Committee Reports" nor the two "Bulletins of the Correlating Committee on Cathodic Protection."



Corrosion Problems

Questions and answers for this heading should be submitted in duplicate if possible, addressed to "CORROSION PROBLEMS", National Association of Corrosion Engineers, 919 Milam Building, Houston 2, Texas. Questions received at the address above above will be sent to E. A. Tice, The International Nickel Co., Inc., N. Y., who is acting editor of the page. All questions will become property of NACE. Questions and replies may or may not be published under this heading and may be answered either by mail directly to the person asking the information, or published under this heading, or both, at the discretion of the editorial staff. Answers to published questions are solicited. Authors of questions will remain anonymous to readers, while authors of answers may remain anonymous if they request it.

QUESTIONS

No. 30—Most paint specifications and directions for application require the surface of structural steel to be "clean-free from loose rust, scale, dirt, moisture, etc." prior to paint application.

How much of these contaminations is it safe to paint over, since it is not practical to remove them all?

What are the best practical cleaning methods?

No. 31—At a fueling station for diesel locomotives, the fuel oil is piped from a 20,000 gallon storage tank through 1800 feet of 6" diam. steel pipe to the locomotive. Rust in this line breaks loose and is carried into the fuel tanks of the locomotive where it causes trouble by clogging filters. The oil remains in the line for an average of four to eight hours.

Is there a method which can be used to prevent corrosion in the 6" line, which will not have an adverse effect on the fuel?

If not, is there an economical material which can be used in place of steel for this pipe line?

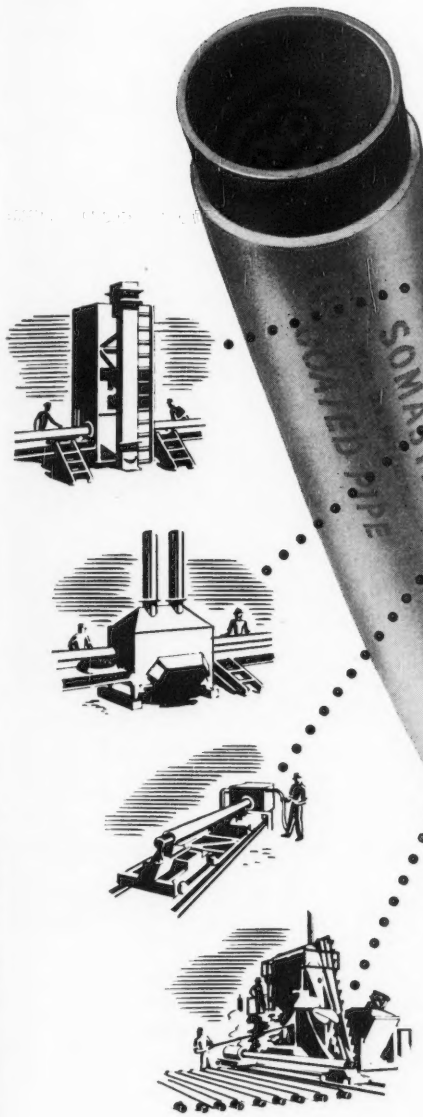
No. 32—We are endeavoring to find a paint system which will give a reasonable life (three months would be acceptable) on the interior of steel tanks in contact with a 12% caustic soda solution and chlorine fumes. The temperature in the tanks may vary between 180 and 250° F.

We have tried red oxide and zinc chromate primers and various types of top coats, such as a vinyl base paint, but these paints do not stand up for more than three weeks.

Is there a satisfactory paint system available which can be applied in the field?

In our repainting procedure the

SOMASTIC* PERMANENCE includes TIME TESTED METHODS of Application



For the past 19 years SOMASTIC PIPE COATING has been applied to pipe by standard practices which only now are being adopted generally by the pipe coating industry. Time has proved them most effective. These methods are—

★ *Thorough cleaning of metal by grit-blasting.*

★ *Pre-heating, followed by hot priming, assuring a firm, lasting bond of coating to steel.*

★ *Selection of materials and manufacture of coating to rigid specifications.*

In addition, SOMASTIC leads in this essential feature—

★ *Application of coating to primed pipe in a continuous process by special* SOMASTIC *equipment to form a dense, compact, uniform and seamless protective coating of great durability.*

The general swing to methods pioneered by SOMASTIC Pipe Coating is another acknowledgment of a fact first shown by the API-Bureau Of Standards Ten Year Pipe Coating Tests . . . and since proved at thousands of corrosive locations.

SOMASTIC

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Unequaled for PERMANENT PROTECTION

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SAN FRANCISCO and WILMINGTON
CALIFORNIA
In the 11 Western States and in Foreign Countries

surface is cleaned with a paint remover. During the 24 hours which elapses between cleaning and repainting, some corrosion of the steel occurs. Can a suggestion be offered as to a method of preventing this corrosion?

No. 33—(a) Can cathodic protection be used on long distance water lines to prevent internal corrosion?

(b) Is oxygen the only cause of corrosion in long distance water pipe lines, when the pH of the water is between 7.5 and 8?

No. 34—What proportions of Bentonite, Gypsum, and sodium sulfate should be used as a backfill for magnesium anodes? What should be the specifications of each ingredient as to chemical analysis and grain coarseness to give the best results?

No. 35—What factors might cause corrosion of Type 347 stainless steel in a 85% nitric acid 15% sulfuric acid mixture which is free of chloride and ferric ions?

No. 36—Can zinc anodes be effectively used to control corrosion and scale formation on cooling tower condenser tubes? If not, is the use of zinc hydrosulphide effective? What minimum concentration is satisfactory, and what is the theory involved?

Do You Have A

CORROSION

PROBLEM?

If you do you are invited to submit it to the editor of this section for an answer by persons who have met problems similar to yours and have found solutions.

Technical Papers Sought On Porcelain Enameling

Best papers on the technology related to porcelain enameling of metal will be given awards in a contest open to graduate and undergraduate students in United States and Canadian ceramic and ceramic engineering schools. First award will be $500; second $300; third $100; fourth and fifth $50 each. The contest closes midnight March 15, 1950, and prizes will be announced at the 52nd annual meeting of the American Ceramic Society, New York, April 24, 1950.

The contest is sponsored by the Central Research Division of Ferro Enamel Corp., Cleveland, Ohio. Judges are Charles S. Pearce, secretary American Ceramic Society; Edward Mackasek, Porcelain Enamel Institute and Dr. G. H. McIntyre, Ferro Enamel Corp.

Rules governing the contest may be secured from the Ferro Enamel Corp., 4150 East 56th St., Cleveland 5, Ohio. Papers submitted should be addressed to Dr. McIntyre at that address.

Title Page for Volume VI Is In January Issue

In response to the request of several librarians who have been binding the technical sections of CORROSION magazine issues annually into a single volume, this issue of the publication will include a title page which will include the name of the publication, the volume number and other pertinent information. This page will be unnumbered so it may be detached and placed at the beginning of Volume VI when the time comes to bind it. It may be found following the annual directory.

Several other recommendations by librarians with respect to the mechanical organization of the magazine have been considered, and some have been adopted, especially with reference to the annual index which appeared in the December, 1949, issue for Volume V. Other suggestions, however, could not be adopted at this time, although they are being kept under consideration.

Gas Turbine and Jet Bibliography Published

A bibliography of books and published reports on gas turbines, jet propulsion and rocket power plants, including sections on aerodynamics, machining, welding, ceramic materials covering data published since 1940 is available from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. The book is 6 x 9 inches and has 49 pages. It is designated as Circular 482.

•

News material intended for publication in CORROSION magazine must be at Central Office on or before the tenth of the month *preceding* date of issue. Skeletonized telegraphic communications are welcomed. The magazine goes to press on the 15th preceding date of issue and no changes can be made after that date.

Tables of Thermal Data On Gases Are Compiled

Sixteen tables of thermal data on gases, emphasizing their important properties in relation to wind-tunnels and jet engines are planned by National Bureau of Standards. Gases to be investigated are dry air, moist air, steam, hydrogen, oxygen, nitrogen, carbon dioxide, nitrogen dioxide, nitric oxide, helium, freon 12 (CF_2Cl_2) and argon. Properties to be tabulated in general as functions of both temperature and pressure are heat capacity at constant pressure, enthalpy (total heat), entropy, Gibbs free energy, compressibility factor, density, ratio of specific heats, velocity of sound, relaxation parameters, viscosity, thermal conductivity, Prandtl number and vapor pressure. The data will cover a range from low pressure up to 100 atmospheres and from very low temperatures to 3000° K.

Three tables now are available for general distribution. Correspondence regarding the tables should be addressed to Joseph Hilsenrath, Heat and Power Div., National Bureau of Standards, Washington 25, D. C.

BOOK REVIEWS

THE STORY OF MAGNESIUM

By W. F. Gross. The American Society of Metals. 5¾ by 7¾ inches. 262 pages. 100 illus. ASM, 7301 Euclid Ave., Cleveland, Ohio. $2.00.

A book which will enable the practical man of industry without professional or technical training to understand the science of magnesium. Includes casting, fabrication, machining, joining surface finishing, riveting and welding.

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The library also makes literatures searches and translations.

Houston U. Corrosion Course Content Given

Content of the University of Houston Course C EG 431—"Corrosion" is given as follows by John P. Roberts, associate professor of metallurgy at the school: Three hours of lecture for one semester at the senior level for all qualified engineering students. There is no laboratory work. Topics considered are: Film growth, electrochemical corrosion, corrosion by acids and alkalis, influence of environment, effect of stress, strain and structure; prevention of corrosion by soluble inhibitors and protective coverings; statistical and mathematical treatment.

Field trips to local industries are scheduled so students may see first-hand how varied corrosion problems are met.

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by W. A. Riley
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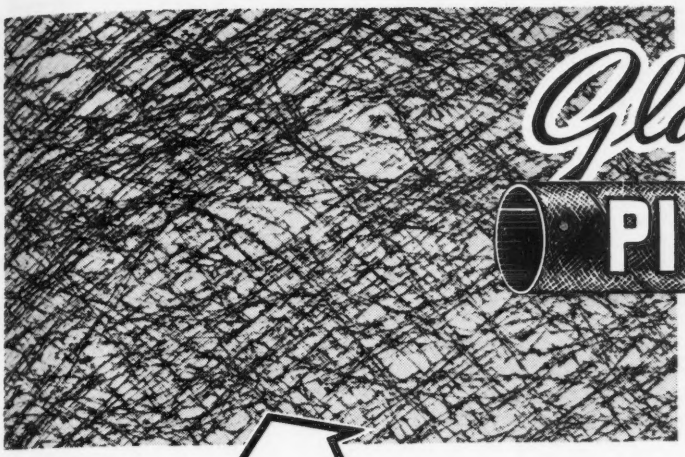

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Corrosion Abstract Indexing Headings Are Changed

Effective with this issue the system under which abstracts will be published in CORROSION will be the same as that designed for indexing the annual volumes of corrosion abstracts and the master punch card abstract file scheduled to be set up at Central Office NACE. The index, major subdivisions of which are given below, is the result of more than two years' work by the NACE Abstract Committee, now headed by Miss Marguerite Bebbington, and Dr. Ivy Parker, editor of CORROSION, and the members of the committee, all of whom have given valuable assistance in the effort to compile an index which would meet the needs of the abstracting system for years to come.

The new system differs radically from that used in CORROSION since its inception in 1945. The philosophy is so different there appears to be no ready method whereby the classifications used heretofore can be related directly for reference purposes to the new method. In any case the necessity for using the old classifications will disappear when the 1946-7-8 abstracts are published.

Following is the list of main and first sub-headings of the NACE Abstract Filing System, July, 1949, Revision. Numbers and headings may or may not be changed in the final form of the index.

1. GENERAL
   1. Miscellaneous
   2. Importance
   3. Reviews
   4. Bibliographies
   5. Directories
   6. Books
   7. Organized Studies of Corrosion
   8. Fundamentals

2. TESTING
   1. General
   2. On Location Tests
   3. Laboratory Methods
   4. Instrumentation
   5. Standardizations and Specifications

3. CORROSION TYPES AND INFLUENCING FACTORS
   1. General
   2. Types
   3. Factors Biological
   4. Factors Chemical
   5. Factors Physical and Mechanical
   6. Factors Electrochemical
   7. Factors Metallurgical

4. CORROSIVE ENVIRONMENTS
   1. General
   2. Atmospheric
   3. Chemicals Inorganic
   4. Chemicals Organic
   5. Soil
   6. Water
   7. Molten Metals

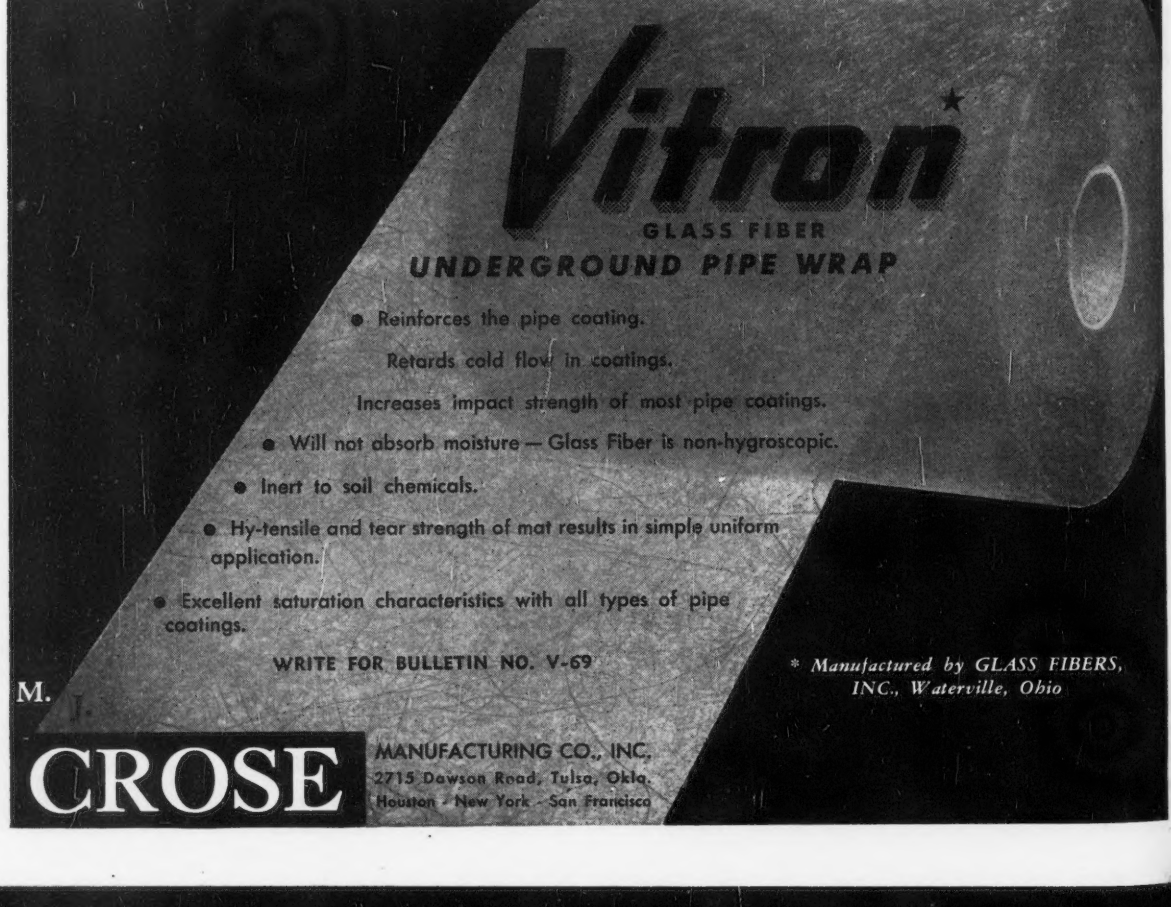
5. PREVENTIVE MEASURES
   1. General
   2. Cathodic Protection
   3. Metallic Coatings
   4. Non-Metallic Coatings
   5. Oil and Grease Coatings
   6. Packaging
   7. Treatment of Medium
   8. Inhibitors
   9. Surface Treatment
   10. Miscellaneous

6. MATERIALS OF CONSTRUCTION
   1. Ferrous Metals
   2. Non-Ferrous Metals
   3. Non-Metallic
   4. Duplex Materials

7. EQUIPMENT
   1. Engines
   2. Valves and Pipes
   3. Pumps and Compressors
   4. Coils and Heat Exchangers
   5. Containers
   6. Structural Shapes
   7. Specifications
   8. Miscellaneous

8. INDUSTRIES
   1. Group I
   2. Group II
   3. Group III
   4. Group IV
   5. Group V
   6. Group VI
   7. Group VII
   8. Group VIII
   9. Group IX
   10. Group X

(Note: Under Section 8—INDUSTRIES, an allocation to groups has been outlined tentatively.)



Comments on
CORROSION
From the Nation's Daily Newspapers

TEXTILE CHEMISTS' CORROSION SURVEY RESULTS REPORTED

(From the DAILY NEWS RECORD, N. Y. C., Dec. 1, 1949)

Results of a survey of corrosion difficulties with stainless steel equipment among members of the American Association of Textile Chemists & Colorists brought a recommendation that dyers and finishers cooperate more fully with equipment suppliers to avoid corrosion difficulties.

A survey of corrosion of stainless steel equipment initiated by J. Robert Bonnar, General Dyestuff Corp., chairman of the association's general research committee indicated complaints were not widespread or serious.

Some of the conclusions derived from the survey were as follows:

1. Substitution of different alloys during wartime shortages was the cause of some breakdowns.

2. Wet processors failed to give manufacturers sufficient information to enable them to recommend the correct alloy.

3. Electrolytic action can cause as much trouble as chemical.

4. Chemical operations producing the greatest damage were those involving strong oxidizing or reducing agents.

5. Chemicals which set up secondary reactions, such as zinc sulfoxalate formaldehyde, hydrogen chloride, hypochlorites and sulfides also caused difficulty.

6. Sulfuric acid in high-temperature water also caused trouble.

7. Metallized colors caused pitting and corrosion in stainless steel kettles. It is believed the 4.5 percent sulfuric acid in the dyebath was responsible.

8. Properly engineered stainless steel equipment should have a life of 20 to 25 years.

9. Molybdenum-containing steels have somewhat better resistance to deterioriation than the regular stainless alloys. Alloys with 28 percent molybdenum, with nickel and chromium, not more than 0.12 carbon and finished with No. 4 polish have proved satisfactory for most uses.

10. Seams, joints and bearing plates are spots where troubles are most likely to occur. Pitting, erosion and corrosion and seam breakage are principal types of breakdown. These may be avoided by immunizing (a phosphoric acid, bichromate treatment) normalizing and butt welding.

AKRON WILL USE INHIBITOR IN SNOW-MELTING SALT

(From Akron, Ohio, BEACON-JOURNAL, Nov. 24, 1949)

Banox, plus a green dye (because it was desired motorists "know that a rust inhibitor was being added") will be added to the salt to be spread on Akron, Ohio, streets this winter to reduce the corrosion of automobile underparts. Last year sodium chromates were added to the salt part of the time and Banox the remainder. The dye was added with the Banox because the latter is colorless.

The article states that damage to automobiles by salt in Akron during war years was $6,000,000. Garages reported repairs on car fenders made necessary by salt decreased tremendously during the past two years.

MAGNESIUM USED TO REDUCE SHIP CORROSION BY CANADA

(From Dayton, Ohio, NEWS and Cincinnati, Ohio, POST, Nov. 24; Akron, Ohio, BEACON-JOURNAL, Nov. 23, 1949)

A method of preventing corrosion of ships' hulls by "strapping strips of magnesium" to the sides of ships, thus preventing "the flow of ions from the iron in the plates of the vessels" is reported in United Press and Associated Press news dispatches. Credited with the discovery is Kenneth Barnard, 38, who with a team of scientists at the Canadian Naval research establishment conducted experiments substituting magnesium for the zinc which previous experiments indicated was unsatisfactory. Drydocking ships once in three or four years instead of yearly was reported to be one of the many advantages of using the protective system.

LaQUE'S TALK ANNOUNCED

(From AMERICAN METAL MARKET, New York City, Dec. 3, 1949)

The talk by F. L. LaQue entitled "Practical Applications of Kure Beach Exposure Tests," before the Baltimore Section NACE December 6 is announced.

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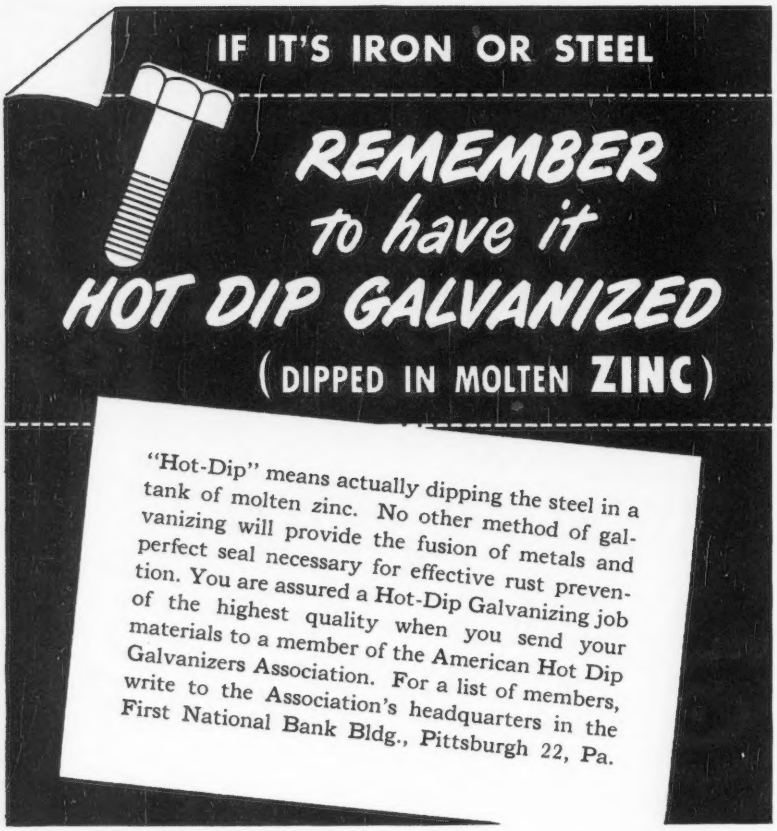

PERSONALS

John W. Nee has been named vice president and technical director of the Briner Paint Manufacturing Co. of Corpus Christi, Texas. **James M. Hammock** was named vice president for sales.

W. R. Caple has been named coordinator of branch office activities for the magnesium sales department of Dow Chemical Co. He will work out of Midland, Mich.

Omar F. Greene has been named New England sales manager for Carpenter Steel Co. with headquarters in Hartford, Conn. **John W. Thompson,** formerly manager of alloy steel sales has been named manager of sales development, succeeding Mr. Greene at Reading, Pa.

DEATHS

W. A. Royston, Jr., 65, founder and chairman of the board of directors, Royston Laboratories, Inc., Blawnox, Pa., died November 26, 1949. A member of NACE for several years he was widely known for his achievements and interest in the field of corrosion.

A list of addresses of new members and changes of addresses of old members is a monthly feature of CORROSION magazine.

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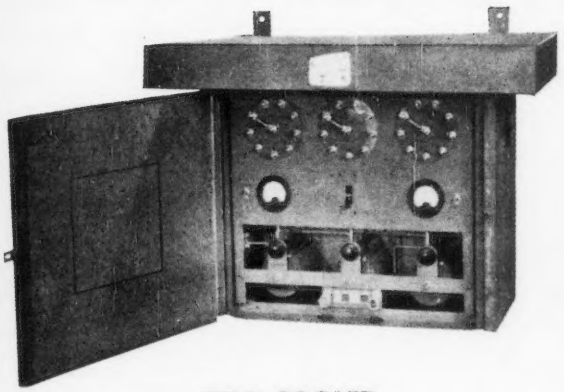

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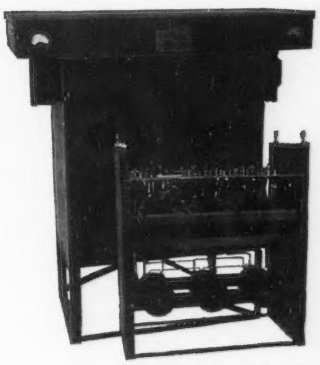

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NEW PRODUCTS—Materials—Service—Literature

Ebasco Services, New York, designed and is supervising the construction of a 170-mile, $10,000,000 22-inch natural gas pipe line with a capacity of 230,000,000 cubic feet daily to the Oak Ridge, Tennessee atom plant. The pipe is being equipped with fully automatic main line valves and will be buried throughout its length to minimize sabotage. Multiple river crossing will be provided. The line also is expected to provide natural gas to the Knoxville, Alcoa and Maryville area this winter. It is scheduled for completion in December.

●

Twelve samples of automotive lubricants may be tested at once on a new Sohio Poly-Veriform Lubrication Tester manufactured by the Precision Scientific Co., 3737 W. Cortlandt Ave., Chicago 47, Ill., in cooperations with the Standard Oil Company of Ohio. The device is designed to study corrosion characteristics, oxidation stability and varnish and sludge formation tendencies of lubricating oils. Manufacturers claim 10-hour tests on the device are equivalent to the 36-hour L4 Chevrolet Test (ASTM). Easy cleaninng also is claimed. In operation highly polished pieces of bearing metal, after weighing, are placed in 100 grams of oil sample. A hardened steel drill rod weighing about 600 grams is placed on the bearing metal to approximate the thrust load of a bearing. The set up then is heated to 325 degrees F., the drill rod rotated at 625 RPM while air is bubbled through the oil at the rate of 70 liters an hour. The bearing piece is weighed after the test to determine the degree of corrosion.

●

Stainless Steel tapered precision-bore metering tube and "float" are features of a new Fischer & Porter Co., Hatboro, Pa., gas flowmeter called "Floguide." An affixed metering scale registers direct reading of flow rate. Available capacities are 45 to 16,000 standard cubic feet of carbon dioxide per hour, 200 to 76,000 SCHF hydrogen and comparable capacities for other gases. They can be furnished to withstand 600 psig working pressure all sizes. Temperature limits are those of commercially-available packings.

●

St. John X-Ray Laboratory, Califon, N. J. has received 350 millicuries source of Cobalt 60. This radioactive material will be used in place of radium. Because Cobalt 60 has a smaller focal point spot size than an equivalent amount of radium, the laboratory says, better results can be obtained by use of this new radioisotope.

●

"Lecite" Claimed by Electro Chemical Supply & Engineering Co., 750 Broad Street, Emmaus, Pa., to be inert to solvents, fats, oils, grease, alkalis and acids, except strong chromic, nitric and sulfuric over 60 degrees Be at 375 degrees F, is a thermoseting synthetic resin cement. Its application is in joining acid-proof brick. The Electro Chemical Supply & Engineering Co., formerly was located at Paoli, Pa. H. D. Fowler Co., Inc., Seattle, Wash., has been named the company's Northwestern agent.

●

Threading Stainless steel fittings at high production rates is possible with properly trained personnel and proper tools, Cooper Alloy Foundry, Hillside, N. J., advises. Details of correct procedures and case histories are included in a folder "Don't Fear Threading of Stainless," available on request.

●

"Perma-Tube" a plastic-coated steel tubing manufactured by Jones & Laughlin Steel Corp., originally for manufacturers of television antennae, now is being used as a structural substitute for masonry columns or metal support columns. The steel tubing is cleaned, dipped in a pre-treatment material called Vinsynite, then coated inside and out with a finish coating of vinyl resin base in which there is aluminum pigment. After baking in an oven the tube is ready for use. High resistance to acid, alkalis and corrosive environments is general is claimed. The material has withstood 950 hours of an accelerated salt-spray test.

●

Plastisols Based on Geon paste resin 121, a product of B. F. Goodrich Chemical Company are being used successfully to single dip plating racks for electroplating service, according to the Goodrich company, 324 Rose Building, Cleveland 15, Ohio. Thicknesses ranging from a few mils to ¼-inch or more per dip are possible, the Michigan Chrome and Chemical Co., Detroit, Mich., fabricators of the plating racks claim.

●

Hagan Automatic Degasser, manufactured by the Hagan Corp., Pittsburgh, produces continuously and automatically an approximately 50-50 split in a flowing steam sample—one fraction of the condensed steam containing any dissolved solids that may be present and the other any dissolved gases. Tests have indicated the new degasser will completely eliminate carbon dioxide from the fraction containing dissolved solids and ammonia has been virtually eliminated. The fraction of the condensed steam containing dissolved solids is run through a cell where its electrical conductivity is tested, providing an index of steam purity, accurate because the influence of gases has been eliminated. Short time intervals for the passage of the steam makes correlation or recorder charts more practical. A second cell measures conductivity of the gas fraction and both may be divirted for chemical analysis.

●

Paint Remover, reported in "The Coating Corner" a publication of Brooklyn Varnish Mfg. Co., Inc., Brooklyn, N. Y., which removes almost 100 percent of paint in comparison to 90 to 92 percent by other removers has been developed. According to Wright-Paterson Field Report No. PB-97658, it is non-corrosive, remains stable up to six months in storage and washes off easily under high pressure water. Basic formula is as follows: (All percentages by weight) Methylene chloride 76.5%; Methyl alcohol 6.5; cellosolve 4.0; methyl cellulose 2.0; wetting agent 5.0; paraffin wax 3.0; water 3.0

●

Duriron Company, Inc., 17 East 42nd St., New York 17, N. Y. is offering the following bulletins on its products: (Write to The Duriron Co., Dayton 1, Ohio, for copies of these bulletins).

816—Model 40, Series R, corrosion-resisting, self-priming Durcopumps, made in 12 materials from cast steel to Duriron. This pump, the company says, cuts priming time 66⅔% over old models, and has handled, on test, as much as 54 cf air per minute without losing prime.

812-A—On the installation and operation of Durcopumps. This bulletin supercedes No. 812, which should be thrown away. This bulletin covers all centrifugal pumps made by the company during the past 20 years.

637—Covering the new Durco Type B Corrosion-resisting plug valves, made in new designs to more fully utilize the physical, metallurgical and corrosion-resisting characteristics of a wide range of alloy bodies. These include Durimet 20, Chlorimet 2, Durco D-10, pure nickel, Inconel, Monel and Ni-resist. Features are: Hard, hardened or hard-faced plugs, with a flexible shank. Grease grooves in all plugs, cut after grinding and lapping. Teflon diaphragms. Proper plug taper.

●

ZK60, An Improved magnesium extrusion alloy containing six percent zinc and one percent zirconium has shown increased toughness, relative insensitivity to notch effect and good impact and fatigue strength. High strength properties are the result mainly of small grain size. Other factors contributing to strength are extrusion conditions. Floor beams of Douglas DC-6 planes among other plane components are made of the material.

●

"Dowell Magnesium Anodes" a bulletin issued by Dowell, Inc., Tulsa, Okla. gives basic information on the use of magnesium for impressed currents on metal structures.

●

International Oil Equipment Co., Inc., New York City, has been named exclusive export representative by The Midwestern Engine and Equipment Co., Tulsa, Okla. Midwestern distributes exclusively several lines of pipeline and oil field equipment, including Coromat pipe wrap, Glasfab, Kapco Rock Shield, and the Beacon Light Plant, a new addition.

●

Fischer & Porter Co., Hatboro, Pa. will hold its next instrumentation course January 23-27.

Corrosion Abstracts

Index To CORROSION ABSTRACTS

GENERAL

• Miscellaneous

The Protection of Steel Against Atmospheric Corrosion and Marine Fouling: Discussion. Iron and Steel Institute. *J. Iron Steel Inst.*, **161,** No. 2, 91-102 (1949) Feb.

Discussion on the following papers: "First Report of the Methods of Testing (Corrosion) Sub-Committee" and "Service Trials of Painting Schemes Applied to Steel-works Gantry," both by J. C. Hudson; "The Protection of Iron and Steel by Various Non-Metallic Coatings," by J. C. Hudson and T. A. Banfield (noted in B.N.F. Bulletin 225, March, 1948, p. 84); "Studies on Anti-Fouling Compositions," by H. Barnes; "Service Tests of Experimental Anti-Fouling Compositions," by H. Barnes, M. W. H. Bishop and K. A. Pyefinch (noted in B.N.F. Bulletin 223, Jan., 1948, p. 15); "Cementiferous Paints," by J. E. O. Mayne and R. S. Thornhill, and "Marine Exposures of Cementiferous Painting Schemes," by K. A. Pyefinch (both noted in B. N. F. Bulletin 230, Aug., 1948, p. 250).—BNF.

• Reviews

Corrosion. (University Research and Teaching in U. S. A. M. G. Fontana. *Ind. Eng. Chem.*, **41,** No. 6, 97A-98A (1949) June.

Brief details are given of two courses on corrosion at Ohio State University. Apart from this, only superficial reference to research, although mention is made of various universities where teaching or research activities proceed. —BNF.

Chemistry Research 1947. (Corrosion Investigations at the Chemical Research Laboratory, Teddington.) Chemical Research Board. Brochure, 1949, 91 pp. H. M. S. O.

This report follows quickly on that for 1938-46, the corrosion section of which was noted in B.N.F. Bulletin No. 230, Aug., 1948, p. 251. Present report includes (pp. 8-28) testing technique (immersed: high- and low-speed rotor, electrochemical measurements, and "orifice plate"; atmospheric: intermittent spray and beaker type); organic corrosion inhibitors; culture of sulfate-reducing bacteria, and inhibitory action of antibiotics and antiseptics on these organisms; electron micrographs of the bacteria.—BNF.

Scientific Attack on Corrosion Under Way. *Chem. and Eng. News,* **25,** 1859 (1947) June 30.

Reviews papers presented at the first University Conference on Corrosion and Metal Protection at the Museum of Science and Industry in Chicago, June 11 through 13.—BLR.

Putting Ocean to Work for Industry . . . Logging Corrosion Data. *Business Week,* No. 1034, 60, 62, 64 (1949) June 25.

Photographs depict tests run at Kure Beach. Research setup is described. Location of stations, scope of testing, usefulness to industry, companies involved in research, and the stress placed on "research" basis by F. L. LaQue are discussed.—INCO.

Companies Unite Against Ravages of Salt Water in Research at Kure Beach Ocean Laboratory. Warren W. Burns. *Oil and Gas J.*, **46,** 107-108, 111 (1947) June 28.

Describes research facilities and programs for prevention of salt-water corrosion of metals, for prevention of fouling, and for prevention of marine-borer attack on wooden structures, at Kure Beach, N. C.—BLR.

Corrosion and Protection of Metals. (Sir) Edward Appleton. *Civil Eng.*, **42,** No. 497, 476 (1947).

Corrosion of metals is reviewed, and reference is made to work at the Chemical Research Laboratory, Teddington. —MA.

• Organized Studies

Research Toward Development of Non-Corrosive Metals and Magnetic Alloys, and the Production of Magnetic Alloys by Powder Metallurgy. (U. S. Dept. of the Army, Contract No. W36-039-sc-32033.) M. A. Streicher, Lehigh Univ., Bethlehem, Pa. Sixth quarterly report, **3,** No. 132, 1 (1947) Dec.

This study, the first in a series on the mechanism of corrosion of light alloys, includes a critical review of the dissolution of aluminum in electrolytes. Experimental work on the solution of commercially pure aluminum in sodium hydroxide relates weight loss and rate of solution to such factors as the time of immersion, temperature, concentration, external current, and additions of gelatin and potassium permanganate. Dissolution phenomena are explained in terms of the electro-chemical theory.

When aluminum dissolves in sodium hydroxide solutions, hydrogen is evolved and a precipitate forms on the metal surface which increases the rate of dissolution. This rate increase is diminished until a constant is reached. The effect of immersion time on the weight loss is designated by a power function. The instantaneous rate of dissolution is directly proportional to the weight loss and inversely proportional to the time of immersion. The constant of proportionality in this relationship applies throughout all ranges of temperature and concentration studied.

Electrode potential measurements made on dissolving specimens revealed that the potential changes to more noble values during the dissolution process. These potential changes seem to be a function of the precipitate rather than the result of any changes occurring in the solution. Plots of electrode potential against rate of dissolution, which can be converted to current density of the local cells, give straight polarization lines, the slopes being directly proportional to the pH of the solution.

Neither the weight loss nor the rate of dissolution can be related to any property of the solution as a function of the concentration over the entire range. The effect of concentration on the weight loss is also expressed as a power function.

The effect of temperature on the weight loss is given by an exponential function, and its effect on the rate of dissolution follows the Arrhenius equation. An increase of 10° C. approximately doubles the dissolution rate.

When aluminum in 0.30 normal sodium hydroxide solution is made cathodic by an external current, the loss in weight drops only slightly as the current density is increased. But when it is made anodic there is first a range of current densities in which there is no apparent effect on the weight loss; this is followed by a range in which the dissolution rate is directly proportional

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to the density of the external current. In the first stage dissolution results from both local cell action and the external current; as the external current density increases, local cell action decreases due to the "difference effect," until it is almost completely suppressed. At this point the weight loss is electrochemically equivalent to the current passing through the cell. In 1 normal solutions the transitions between these various phases are less pronounced than in 0.3 normal solutions as the current density is increased, and local cell action can not be reduced to zero. The difference effect in 1 normal solutions is directly proportional to the current density up to 20 ma per sq. dm; at this point the difference effect falls off. This linear relationship holds true also in 0.3 normal solutions, but the difference effect has a definite positive value at zero current density resulting from the influence of concentration gradients set up in the more dilute solution.

The effects of agitation, added gelatin, and temperature changes indicate that the rate-controlling reaction is a homogeneous chemical reaction.

About 0.1% potassium permanganate is required to depress the solution rate of commercially pure aluminum in 0.3 N sodium hydroxide. In smaller quantities it has an accelerating effect.

The difference effect is the counterpart of cathodic protection, and the same conditions apply when the direction of the external current is taken into consideration. Its limiting value is reached when the local anodes are polarized to the open-circuit potential of the local cathodes, a condition met in 0.3 N solutions. The difference effect is as reproducible as other dissolution tests when the change in dissolution rate with immersion time is considered.

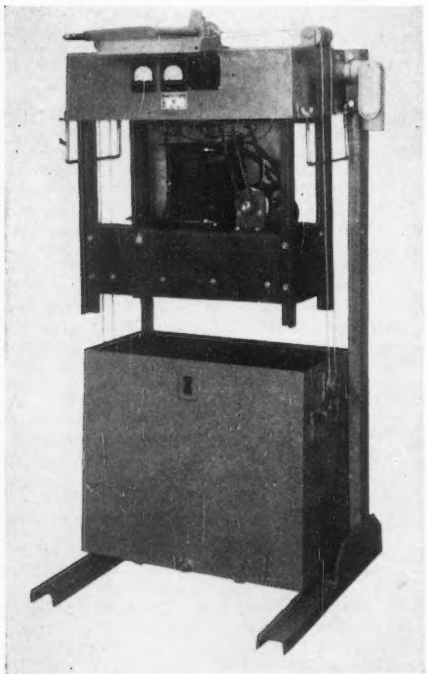
The rate of dissolution is determined by the rate of the cathodic processes, which probably constitute one of the steps in the reaction series in which hydrogen is liberated at the cathodes. Diffusion effects do not appreciably influence the rate of dissolution under freely dissolving conditions.

The samples, all taken from one 0.0225-in. sheet of 2 S-O-aluminum of about 99.1% purity, were circular in design to minimize edge effects. They were pretreated in 6 N sodium hydroxide to produce a uniform surface, rinsed in water, and immediately immersed in the test solution. After completing the test, the surface precipitate was removed under running water, and the samples dried in an electric oven at 110° C, cooled in a desiccator, and weighed.

A bibliography of 111 references is included.

Research Toward Development of Non-Corrosive Metals and Magnetic Alloys, and the Production of Magnetic Alloys by Powder Metallurgy. MICHAEL A. STREICHER, BERNT ROALD, GEORGE CONDON, AND FREDERIC KEIHN. Ninth quarterly report, **4**, No. 36 (1948) July.

This ninth progress report in the series consists of four sections. Three of them, preliminary to future research, concern: 1) a literature survey of information on the corrosion of magnesium in various electrolytes, 2) the corrosion rate of aluminum under accelerated conditions, particularly in solutions containing hydrogen peroxide, and 3) controlling factors in galvanic corrosion. In



• "NEMCO" Class 930 Selenium Rectifier, Oil Immersed Type. Portable, tank-lowering windlass is shown on top of unit. Oil Tank is in lowered position for inspection. Cover has been raised over instruments and tap-changing switch.

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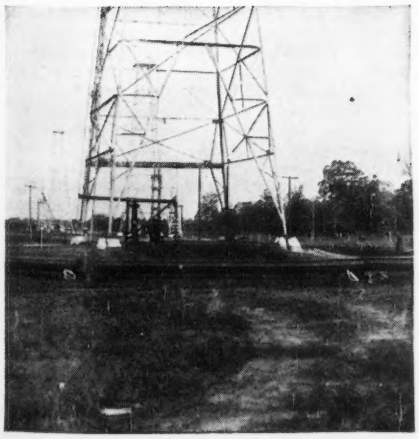

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the fourth section, experimental work on the mechanism of dissolution of commercial 2S aluminum, 99.2% pure, in sodium hydroxide solutions, which was reported in detail in Part 6, is extended to purer compositions, including 99.85%, 99.95%, and 99.99% aluminum, and to 52S aluminum alloy containing 2.5% magnesium. Alkaline solutions were used for most of these experiments, although some preliminary test runs also were made in acids.

Aluminum of higher purity than 2S has a lower dissolution rate, the rate decreasing as the purity increases. The mechanism of dissolution appears to be the same, the impurities in the metal depositing on the surface and increasing the dissolution rate. For the 52S metal, this rate is constant with time, since the impurities do not deposit on the surface but fall to the bottom of the solution. These observations are supported by electrode potential measurements. During dissolution, the potential of aluminum of 2S or higher purity changes continually toward a more cathodic value, whereas that of 52S remains constant.

In hydrochloric acid solutions, the effect of impurities on the rate of dissolution is more pronounced. Thus in 1 N acid solution, 2S aluminum dissolves rapidly, whereas a very pure composition is not attacked at all. Aluminum alloys are generally more resistant to acids of a given concentration than to alkaline solutions of the same concentration. All results are preliminary.

PDC Comment: Other reports in this series are either preliminary in nature, repeat the information abstracted, or relate to work on magnetic alloys.

The investigation of the magnetic alloys was restricted to an evaluation of the corrosion properties of commercial, magnetically soft materials. Preliminary tests of these in a salt-spray cabinet indicated that the iron-nickel alloys are superior to other alloys. A number of variables which might affect the results were not controlled.

A correlation between loss in weight and dimensional change of cylindrical specimens is now being investigated as a better means for evaluating corrosion behavior.

The rate of dissolution is determined by the rate of the cathodic processes, which probably constitute one of the steps in the reaction series in which hydrogen is liberated at the cathodes. Diffusion effects do not appreciably influence the rate of dissolution under freely dissolving conditions.

The samples, all taken from one 0.0225-in. sheet of 2S-O aluminum of about 99.1% purity, were circular in design to minimize edge effects. They were pretreated in 6 N sodium hydroxide to produce a uniform surface, rinsed in water, and immediately immersed in the test solution. After completing the test, the surface precipitate was removed under running water, and the samples dried in an electric oven at 110° C, cooled in a desiccator, and weighed.

A bibliography of 111 references is included.—PDA.

Calculations for Reactions of Chromium, Molybdenum, Titanium, and Tungsten with Oxygen, Nitrogen, Hydrogen, Carbon, and Sulphur. J. J. WARD, J. P. RAY, AND S. A. HERRES. (Douglas Aircraft Company Rep. R-108, 1948, 97 pp.; *Nuclear Sci. Abs.*, **2**, 208 (1949).

Presents information obtained in a study of the theoretical application of physical-chemical data to the determination of the conditions for reactions of chromium, molybdenum, titanium, and tungsten, with oxygen, nitrogen, hydrogen, carbon, sulfur, and refractory oxides. Practical considerations including availability and cost, indicate that primary emphasis should be laid on the metals chromium, molybdenum, titanium, and tungsten as bases for alloys with good strength at elevated temp. The strong reactivities of these metals with atmospheric oxygen and nitrogen, with hydrogen and carbon, and with refractory oxides, which are ordinarily used as furnace linings for containing other molten metals, lead to serious problems in producing the metals and in utilizing them for elevated-temp. service. Although very few direct experimental data are available, it is possible to calculate, by means of basic physical-chemical principles, the conditions under which reactions could occur.—MA.

Abstract Section Style Outlined

For ease in locating reference data, CORROSION uses a uniform style in its Abstract Section.

The abstracts first are broken down into major classifications of the more common types of corrosion literature. In each review the title of the article is presented in bold face type, followed by the author's name. The publication from which the article was abstracted is printed in italics and is abbreviated in most instances. Following this, in sequence, are the volume (bold face), number in the volume, pages, year and month of publication. In some instances a second reference will be listed in the same manner. This indicates that the article also was published or abstracted in another publication. A brief summary of the article follows the above information and it is concluded with an abbreviation indicating the source of the abstract and contributor. The meanings of these abbreviations usually are listed on the first page of the Abstract Section.

When seeking more detailed data about an abstract, best source of information is the publication in which the article appeared originally. (Listed in italics in the heading.) The contributor of the abstract also may be able to supply additional information. Addresses of most of these publications may be found in the reference section of most public libraries.

• Fundamentals

Hydrogen Overvoltage. A. FRUMKIN. "Electrode Processes." Discussions of the Faraday Society, No. 1, 57-67; discussion, 127-141 (1947).

Shows by a number of independent methods that in the case of hydrogen evolution on mercury from acid solutions, the slowest stage of the reaction is the discharge of hydrogen ion which completely determines the kinetics of the overall reaction. In the case of cathodes with low overvoltage, the rate of the discharge stage also can be determined experimentally; however, the rate is affected also by subsequent stages, such as formation of hydrogen molecules, or the diffusion of molecular hydrogen. The presence of oxide films on the surface of metals has a marked influence. Overvoltage remains unchanged when the anodic process and dissolution of the metal occur simultaneously thus making possible conclusions regarding steady-state potential and rate of dissolution of metal. 43 ref.—BLR.

The Theory of Overvoltage. RENE AUDUBERT. "Electrode Processes." Discussions of the Faraday Society, 1947, No. 1, 72-80; discussion, 127-141.

Correlates and summarizes recent experimental work which makes possible satisfactory theoretical interpretation of many observations. Includes numerous tables and graphs. 14 ref.—BLR.

Studies in Electrolytic Polarisation. II. The Effect of the Solvent on the Hydrogen Overpotential. J. O'M. BOCKRIS. "Electrode Processes." Discussions of the Faraday Society, 1947, No. 1, 95-106; discussion, 127-141.

Hydrogen overvoltage on lead, copper, and nickel cathodes was measured in solutions of hydrogen chloride in methyl

Abbreviations at the end of abstracts indicate source of abstract and contributor; and are as follows:

AER	*Aeronautical Review*, Institute of Aeronautical Sciences, Inc.
ALL	*The Abstract Bulletin*, Aluminum Laboratories, Ltd.
AWWA	*Journal*, American Water Works Association
BLR	*Battelle Library Review*, Battelle Memorial Institute Library
BNF	*Bulletin;* British Non-Ferrous Research Association
CALCO	Calco Chemical Division, American Cyanamid Corp.
CE	*Chemical Engineering*, McGraw Hill Publishing Co.
CEC	Consolidated Edison Co. of New York, Inc.
EW	*Electrical World*, McGraw Hill Publishing Co.
GPC	General Petroleum Corp. of California
INCO	The International Nickel Co., Inc.
IP	Institute of Petroleum
MA	*Metallurgical Abstracts*, Institute of Metals, London, Eng.
ME	Marine Engineering
MR	*Metals Review*, American Society of Metals
NALCO	National Aluminate Corp.
NBS	National Bureau of Standards
RA	*Refrigeration Abstracts*, American Society of Refrigeration Engineers
RM	*Revue de Matallurgie*, Paris, France
RPI	*Review of Current Literature Relating to the Paint, Colour, Varnish & Allied Industries*, Research Association of British Paint, Colour & Varnish Manufacturers, London.
TDD	*Technical Data Digest*, Air Materiel Command—Technical Service Section
UOP	Universal Oil Products
No Code	*Current Technical Literature*, Bell Telephone Laboratories

and ethyl alcohols, ethylene glycol, formic and acetic acids, ether, and dioxane and in mixtures of these with water except in the cases of formic acid and ether. Long time-decay and the effect of stirring were also determined. Results do not agree with known versions of the neutralization or reaction-rate theories. Suggests a catalytic mechanism, in which adsorbed solvent molecules influence the rate of formation of H_2 molecules from hydrogen atoms. 27 ref.—BLR.

Oxygen Overvoltage, Part I. The Influence of Electrode Material, Current Density, and Time in Aqueous Solution. A. HICKLING AND S. HILL. "Electrode Processes." Discussions of the Faraday Society, 1947, No. 1, 236-246; discussion, 248-254.

A thorough survey was made of conditions necessary to obtain reproducible oxygen overvoltage measurements, and an experimental method was developed which gives reliable values. This method was applied to a study of the behavior of 12 different anode metals in alkaline solution over the current density range 10^{-3} to 1 amp. per sq. cm. 23 ref.—BLR.

Investigation of Electrode Reactions by the Method of Charging-Curves and With the Aid of Alternating Currents. B. ERSHLER. "Electrode Processes." Discussions of the Faraday Society, 1947, No. 1, 269-277; discussion, 298-302.

Describes above method and gives results obtained by its use with respect to: kinetics of the formation of adsorbed layers of oxygen and hydrogen on metals and of the dissolution of metals; and of the mechanism of anodic dissolution and passivation of platinum. 21 ref. —BLR.

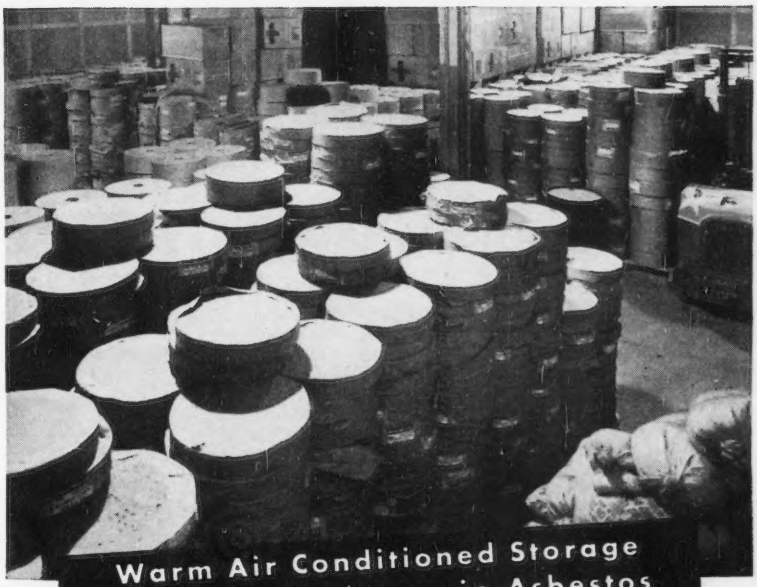
The Standard Electrode Potentials of the Elements. J. O'M. BOCKRIS AND J. F. HERRINGSHAW. "Electrode Processes." Discussions of the Faraday Society, 1947, No. 1, 328-334.

Presents, in tabular form, results of a comprehensive and critical examination and correlation of literature data. 120 ref.—BLR.

The Mechanism of the Formation of Films on Metals. ULICK R. EVANS, Cambridge University. *Corrosion and Mat. Protect.*, **5**, No. 4, 15-10 (1949) July-Aug.

The mechanism of formation of films on metals has been diagrammed to explain important experimental facts relating to the four equations established by Vernon in 1943, viz., the parabolic, rectilinear, logarithmic, and asymptotic growth laws.

Only one arbitrary assumption is made, namely, that oxygen passes into the metal and forms a solid solution, and that nuclei of oxide appear only after a state of supersaturation has been reached. From these nuclei the oxide phase spreads laterally over the surface, explaining the sigmoid curl seen at the beginning of certain oxidation-time curves. The first crystals of oxide are compressed laterally, since the conditions of formation do not allow them to take up an unconstrained shape. The distorted structure is continued both while the oxide spreads laterally over the surface and also when the film starts to increase in thickness. This explains the results of electron diffraction



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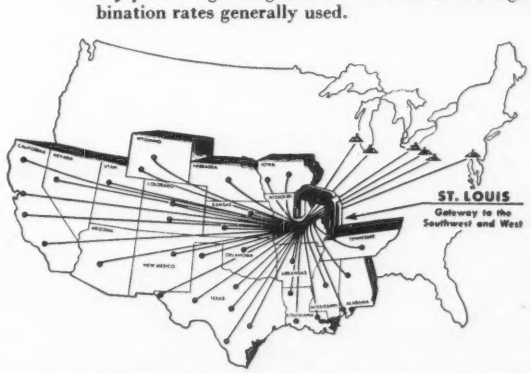

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and x-ray studies and also the wrinkles seen in the films after they have been transferred to a yielding base.

The thickening of the films is considered to be caused by the outward movement of cations and electrons, according to Wagner's mechanism; thus films which have poor electronic or ionic conductivity are protective. Wagner's equations correlate the growth constants of the films with the electrical properties of the film substances. Where the necessary data are available, good agreement is obtained between calculated and experimental values.

As the film thickens, its internal stress periodically causes breakdown, which may occur in different ways. At high temperatures, strain is relieved by plastic flow, without necessarily producing cracks. At somewhat lower temperatures cracking may occur, and at any particular moment, there may be an outer shattered layer overlying a compact inner layer. According to the relative resistance imposed by the two layers, the growth may obey either the parabolic law or the rectilinear law. At still lower temperatures, breakdown may take the form of blistering, leading to a series of cracks parallel to the surface. These act as "cavity barriers" and obstruct passage through the film, so that the rectilinear law is replaced by a logarithmic relation and the parabolic law by an asymptotic relation. Logarithmic growth might also be indicated if oxidation occurs by penetration into the metal along uni-dimensional paths.—PDA.

On the Oxidation of Metals at Low Temperatures, and the Influence of Light. N. CABRERA. *Phil. Mag.,* (vii), **40,** No. 301, 175-188 (1949).

Theoretical. The theories developed by Mott for the oxidation of metals at low temp. are discussed, and are extended to oxides, such as Cu_2O, for which the metal diffuses through the oxide by the mechanism of vacant lattice points. Discontinuities such as intercrystalline surfaces are neglected. It is shown that the logarithmic oxidation law will be valid down to very low temp., and for pressures of oxygen above approx. 10^{-4} mm. mercury, independently of the temp. and the oxide considered. Mott's oxidation model also has been applied to explain the influence of ultra-violet light on the oxidation of aluminum; the rate of oxidation is higher for irradiated samples than under ordinary conditions. The theory developed agrees with the experimental results, and suggests that the influence of light will be observable only for frequencies such that $h\nu > 2$ eV. The limiting thickness of the oxide layer under the influence of light increases by a factor $(\psi\ h\nu)/\psi$. ψ is given by $F = \psi/ex$, where x is the thickness of the layer, e is the electronic charge, and F is the const. field in the oxide layer. —MA.

Electrochemical Assessment of Corrosion-Resistance of Ferrous Alloys. L. CAVALLARO AND A. INDELLI. *Metaux et Corrosion,* **25,** 149-156 (1949) June.

Results of experiments on mechanism and rate of corrosion occurring in plain and alloy steels (13 chromium steel, 18 chromium-8 manganese steel, 14 chromium-1 nickel steel, 17 chromium steel, 18-8). Attacking media: lithium chloride, sodium chloride, potassium chloride, potassium bromide, potassium iodide, sodium sulphate, potassium sulphate. Effects of many inhibitors studied.—INCO.

Activité électrochimique des pellicules de rouille et la corrosion du fer par la rouille en milieu humide aéré voisin de la neutralité (The Electrochemical activity of Rust Films and the Corrosion of Iron by Rust in Damp, Aerated Conditions, at About the Neutral Point). E. HERZOG. *Metaux et Corrosion,* **24,** No. 285, 119-34 (1949) May.

Though the aim of the research reported here was to investigate the electrochemical action between rust and a clean iron surface, several experiments are described in which electrolytic couples between rusted iron and zinc were investigated. The electrochemical characteristics of the rusty iron/zinc couple are the sums of those for iron/rusty iron and iron/zinc. The behavior of iron/rust couples under various conditions is reported. In the presence of oxygen, rust accelerates the corrosion of iron not only electrolytically, but also because of its depolarizing action. —ZDA.

The Analysis of Corrosion-Time Curves. F. A. CHAMPION AND M. WHYTE. *J. Inst. Metals,* **75,** No. 19, 737-740 (1949) May.

Empirical corrosion-time curves usually conform to one of the four typical equations which may be termed rectilinear 1), parabolic 2), logarithmic 3), and exponential 4). Methods are available for accurate fitting of 1), 2), and 4), and a method is now given for 3) as an alternative to the approximation formerly used. The new method is particularly useful for relatively low rates of oxidation or corrosion.—BNF.

An Electric Effect During the Corrosion of Metals in a Magnetic Field. UGO CROATTO. *La Ricerca Scientifica,* **18,** Nos. 5/6, 30 (1948) May/June; *Technical Data Digest,* **14,** No. 8, 53 (1949) Apr.

Investigations into electrochemical aspect of corrosion of metals due to action of free metalloids and metalloids liberated from other compounds across a compact layer of the compound formed, indicated that if a compound possesses semiconductive characteristics the corrosion in the magnetic field is accompanied by an electric effect.

Pittsburgh International Conference on Surface Reactions. Corrosion Publishing Co., Pittsburgh, Pa., viii, 236 p., illus., tables, diagrs. 1948.

One of the aims of the International Conference on Surface Reactions held in Pittsburgh, Pa., June 7, through June 11, 1948 was to re-establish and stimulate the exchange of scientific information between America and Europe. Papers with the following titles were presented and are reproduced in full with appended bibliographies: Properties of Metallic Surfaces, Pulse Polarization Studies of Corrosion Rates, Theory and Technique of Measuring Metal Dissolution Rates, The Measurement of Permeability Characteristics of Anodic Films on Aluminum, The Corrosion of Zinc and Zinc-Coated Steel in Hot Waters, Valence Inductivity and Catalytic Action, The Mechanisms of Some Elementary Surface Reactions, Application of the Electron Microscope in Corrosion Studies, The Preparation of Single Crystals for the Study of Surface Reactions, The Mechanism of the Formation of Films on Metals, Reactions of Metals and Alloys with Oxygen, Sulphur and Halogens at High Temperatures, Studies of Metal Surfaces by Low Temperature Gas Adsorption, Optical Determination of Thin Films on Reflection Bases in Transparent Environments, Some Aspects of Internal Oxidation in Silver, Copper, Nickel and Iron Alloys, A Study of the Difference Effect, Measurement of Galvanic Currents Around an Underground Structure, The Action of Organic Inhibitors in the Acid Attack on Mild Steel, Some Recent Contributions of a British Corrosion Research Group, Investigations of Gas Metal Reactions by Reflection Electron Diffraction, Theoretical and Experimental Investigations About Conjugated Formation of Several Layers in Dry Corrosion, Étude Micrographique de l'Oxydation du Fer et des Transformations du Protoxyde de Fer, Influence of the Condition of Iron and Copper on Oxidation at High Temperatures, Mechanism of the Rapid Oxidation of High Temperature, High Strength Alloys, Surface Preparation by Electropolishing, The "Wetting Effect" Strongly Affecting the Tensile Strength of Solids and Liquostriction, a New Effect Resulting, The Behavior of Oxide Films on Aluminum, The Breakdown of Oxide Films in Acid Vapors, The Reaction of Metals in High Vacuum. —PDA.

The Rate of Solution of Highest Purity Aluminum in Sodium Hydroxide Solutions. M. E. STRAUMANIS AND N. BRAKES. *J. of the Electrochemical Soc.* (U. S. A.), **95,** No. 2, 98-106 (1949) Feb.

A series of dissolution experiments on highest purity aluminum (99.998%) in sodium-hydroxial solutions ranging from 0.1 to 5-normal has been carried out. The rate of solution parallel experiments shows deviations up to ∓ 30 percent from the average value. Homogenization attempts did not improve the results. The rate of solution in sodium-hydroxial (up to 0.5 or 1 normal) is proportional to the cube root of the concentration of sodium-hydroxide. In the region between approximately 0.5 and 3-N the rate increases proportional to the concentration. Then follows a sudden jump and at concentrations above 4-N the rate increases again, probably proportional to the concentration. At concentrations higher than 5-N, the dissolution process is very irregular and deep pits are formed. Upon reducing the concentration below 5-N sodium-hydroxide (the aluminum plates were washed and the dissolution continued in fresh sodium-hydroxide of lower concentration) the rate of solution drops only gradually, remaining considerably higher than when working with increasing sodium-hydroxide concentrations. When the corroded surface was removed mechanically, the previous velocity could be observed within the limits of reproductibility. (Authors' abstract.)—ALL.

Corrosion Prevention—I. Influence of Correct Design. G. T. COLGATE. *Met. Ind.,* **74,** No. 7, 123-5 (1949) Feb. 18.

The first article in this series contains an account of the general causes of corrosion, and shows how attention to

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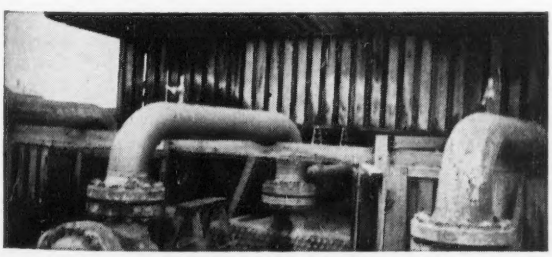
*Underground. POLYKEN No. 882 (black) being applied to joint in field.



*Aboveground. POLYKEN No. 888 (aluminum) coating on exposed pipe at compressor station.

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certain details in the design of a metal article or structure can help to prevent it. In particular, the subject of contact corrosion between different metals is discussed. The author points out that the series of standard electrode potentials of metals can be very misleading, and quotes a more practical series drawn up by La Que and Cox. In this, which applies strictly only to metals immersed in sea water, magnesium and its alloys come first, followed by zinc, which can therefore protect any metal except magnesium. Aluminum may be used safely in contact with zinc or cadmium, coatings of which are often used to prevent contact between aluminum and steel.—ZDA.

Corrosion, Passivity and Passivation from the Thermodynamic Point of View. M. POURBAIX, U. of Brussels. *Corrosion*, **5**, No. 4, 121-133 (1949) Apr.

When a metal is in contact with an aqueous solution, its surface state varies strongly according to the circumstances existing. If the metal is covered with a protective film, a state of passivation exists. When the surface actually remains metallic, it is a state of passivity. A metal does not corrode unless it is unstable with relation to its corrosion products. An oxide or other compound cannot form a protective film on a metal unless it is unstable at the same time with relation to the metal and with relation to the constituents of the solution. It is convenient to represent circumstances of energetic equilibrium between a metal and composition to which this metal can give rise to corrosion or passivation by diagram where abscissa represents pH of solution, ordinate potential of equilibrium E.—TDD.

Corrosion Theories: Rust: How It Is Formed and Why it Must Be Removed. Machine Production. *Canada's Foundry J.*, **22**, No. 4, 23-24 (1949) Apr.

Corrosion theories postulated prior to the now generally-accepted electrolytic theory are reviewed. Electrolytic theory is discussed in detail.—INCO.

Corrosion. R. ERGANG, G. MASING, G. WASSERMANN AND W. WIEDERHOLT. FIAT Rev. German Sci., 1939-1946: General Metallurgy, 1948, 257-286). (In German.)

E. and M. review recent German contributions to the general theory of corrosion, with particular reference to theories developed by Muller, and criticism of these theories by other workers. The problem of passivity is considered, and 43 references are given to recent work. Wassermann discusses methods and techniques for examining stress-corrosion properties, the form of specimen to be used, and the relationship between the stress and the extent of the corrosion. The theory of stress corrosion is briefly dealt with. Wiederholt summarizes recent work on natural and laboratory methods of examining corrosion resistance. There is a bibliography of 169 references.—MA.

Intergranular Corrosion of Pure Aluminum in Relation to the Behavior of Grain-Boundaries During Melting. G. CHAUDRON, P. LACOMBE, AND N. Y. YANNAQUIS. Translated from the French. *Nature*, **162**, 854-855 (1948) Nov. 27. *Comptes Rendus*, **226**, 1372-1373. (1948).

Chalmers showed that the grain boundaries of high-purity tin have a melting temperature lower than that of bulk tin. A similar effect was observed in the case of high-purity aluminum by use of a simple device. When the metal was heated for a long time near its melting point, an inversion of the corrosion was observed; for example, hydrogen chloride dissolved only the bulk of the crystals, leaving their boundaries uncorroded as a very thin partition. Includes micrographs. —BLR.

TESTING

• General

Jet-Test for Determining the Thickness of Lead Coatings. R. A. F. HAMMOND, Minst. Supply, Armament Research Estab., Advance Copy, 1948; *J. Iron Steel Inst.* (Abs.), **161**, 68 (1949).

The preparation and standardization of a jet-test reagent suitable for determining the local thickness of lead coatings is described. The solution consists of glacial acetic acid 1, hydrogen peroxide (5% H_2O_2) 1, and distilled water 3 parts by volume.—MA.

Tests on New Paint Inhibitors. Iron and Steel Institute, British Iron and Steel Research Association and Others. *Paint Manuf.*, **18**, No. 9, 306 (1948).

Summary of an interim report (6 months' exposure) on 100 priming paints now being tested. The results indicate the importance of film thickness, and that a marine exposure was more destructive than exposure to an industrial atmosphere.—RPI.

Pilot Plant Corrosion Tests. M. G. FONTANA. *Ind. Eng. Chem.*, **41**, No. 3, 101A, 102A; **41**, No. 4, 103A, 104A; **41**, No. 5, 95A, 96A (1949) Mar., Apr., May.

Discusses value of such tests on materials of construction; handling of specimens; exposure time; use of correct temperature and corroding medium; testing actual parts.—BNF.

New Corrosion Test for Plastics. W. H. ADAMS AND H. H. LEBACH, Haveg Corp. *Chem. Eng.*, **56**, No. 7, 98-101 (1949) July.

Explains and describes a statistical laboratory method which involves several variables, and which seems to duplicate field results with considerable accuracy. Article shows how method has worked in evaluating resistance of various grades of the material Haveg, which is made of phenolic or furan resin, filled either with asbestos or graphite. Discussion includes previous test methods, interpretation of results of new test procedure, rating system for Haveg, over-all rating and the fact that the test checks with field results. —INCO.

Significance of Chemical Tests in Lubricating-Oil Specifications. W. EISMANN, JR., E. F. Houghton & Co. Paper before Am. Soc. of Lubrication Engs., 3rd Ann. Conv. *Power*, **93**, No. 3, 97-99 (1949) Mar.

Explanation of what lube-oil chemical tests mean. Corrosion tests are defined as tests to establish potential corrosivity of a lubricant. Oxidation tests are defined as tests to determine life expectancy of oil.—INCO.

Bearing Corrosion Test for Lubricating Oils. E. C. HUGHES, J. D. BARTLESON AND M. L. SUNDAY, Standard Oil Co. of Ohio. *Anal. Chemi.*, **21**, No. 6, 737-743 (1949) June.

Description is given of a thrust bearing apparatus adaptable to the Sohio oxidation test for lubricating oils. Correlative information is obtained on the oxidation characteristics of the lubricating oils. The procedure can be used to study the use of corrosion inhibitors in combination with corrosive detergent type additives.—INCO.

The Use of Silver/Silver-Chloride Reference Electrodes in Dilute Solutions. P. T. GILBERT. "Electrode Processes." Discussions of the Faraday Society, 1947, No. 1, 320-325; discussion, 325-328.

Shows that the silver/silver-chloride electrode is suitable for use in corrosion work at temperatures up to at least 85° C and in dilute solutions containing as little as 10 ppm chloride. Points out desirability in corrosion studies of being able to compare directly potentials measured at different temperatures. Discusses basis on which such comparison may be possible.—BLR.

Solderless-Type Wire Terminals. T. C. FREEDOM, Aircraft Marine Products, Inc. *Elec. Mfg.*, **43**, No. 5, 104-109+ (1949) May.

Special surface treatment can be used to add corrosion resistance to all types of copper treminals. Stability of conductivity is sufficiently high that calibrated leads for an instrument shunt may be terminated with the corrosion-proofed solid conductor type terminals without fear of later instability. Graph shows process produces stable electric junction and lower electrical resistance. Crimp performance and corrosion instances are evaluated by measuring junction resistance, temperature rise and voltage drop at rated current under 30-day salt spray test, with readings taken at the end of successive 3-day test cycles.—INCO.

A Satisfactory Salt Spray Cabinet Design. Report of the Mineral Dressing and Metallurgical Laboratories, Bureau of Mines (Canada) Investigation No. 2518, 17th February 1949.

The research described here was performed under the sponsorship of the National Research Council Associate Committee on Corrosion Research and Prevention for the purpose of determining whether or not the salt spray cabinet at the Bureau of Mines conformed in every respect with present day requirements. The experimental procedure is presented, and the results obtained are tabulated. In view of the conclusions drawn, the use of a salt spray cabinet of the design shown in a diagram accompanying the report is recommended. —ALL.

Insulation of Dissimilar Faying Metal Surfaces. B. W. FLORESCH. *Western Metals*, **5**, No. 4, 22-23 (1947). *Chem. Abs.*, **41**, 3423 (1947).

Among dissimilar substances studied were 24S-T Dural with cadmium plated 1025 steel, AMC52S-H magnesium with

18-8 stainless steel, AMC52S-H magnesium with 24S-T Dural, and AMC52S-H magnesium with 24S-T Alclad. All specimens were assembled with cadmium-plated bolts which were dipped in zinc chromate primer and inserted while wet; 25 aluminum washers were used under the bolts and nuts. After assembly specimens which contained magnesium were given four coats of $ZnCrO_4$ primer. When thoroughly dry they were suspended with glass hangers in salt-spray cabinet. Dural was anodized and coated with two coats of $ZnCrO_4$ primer. Cadmium plated steel was given one coat of $ZnCrO_4$ primer. Stainless steel was rinsed in 2% HNO_3 for two min. and given two coats of $ZnCrO_4$ primer. Aluminum to cadmium plated steel group showed no corrosion after 1007 hr. in salt spray. Magnesium to aluminum combinations showed signs of corrosion after 72 hr. and excessive corrosion after 255 hr.

Tropicalization of Radio and Radar Equipment. W. C. Ellis and M. M. Baldwin, U. S. Air Material Command, Contract No. W33-038-ac-14479 (16030), 1948; *Prev. Det. Abs.*, **6,** Lac 6-8 (1949).

Films of a clear vinyl resin lacquer and a clear p-phenyl-phenolic varnish were tested for wet scratch resistance, breakdown voltage and weight loss or gain, under artificial exposures. The results are compared with the effect of tropical exposure. p-Nitrophenol and 3, 5 diiodosalicylic acid (fungistatic agents) were exposed to heating at 85° C and 100° C, and to leaching in distilled water. The effect of U.V. light on fungistatic coating material films was also investigated.—RPI.

Tropicalization of Radio and Radio Equipment. W. C. Ellis and M. M. Baldwin. U. S. Air Material Command, Contract No. W-33-038-OC-14479 (1948); *Prov. Det. Abs.*, **5** E 20 and F 30 (1948); cf. *Review*, 330, 421 (1948).

Accelerated laboratory tests of tropical serviceability of fungicidal coating materials included 1) 7 days at 30° C 96-8% R.H.; 2) 10 days of 9 hrs. 25° C 50% R.H.; 15 hrs. 30° C 96-8% R.H.; 3) 3 days at 85° C. This treatment did not produce all the physical changes occurring during 7 months' natural exposure. The 3 days at 85° C lowered the toxicity of most fungicides. Combinations of salicylanilide and phenyl mercuric-o-benzoic sulphimide, 2, 3-dichloro-naphthoquinone-1, 4 and 3, 5-di-iodo-salicylic acid and ethylene thiocyanate were resistant to heat. The activity of fungicides was dependent on the medium in which they were used. Preliminary results of tests cycling between —55° C under vacuum and 30° C at 96% R.H. are reported.—RPI.

Effect of Temperature on the Rate of Blister. Failure of Finishes on Steel in Water Immersion Tests. J. A. Boylan and R. I. Wray. *ASTM Bull.*, **1949,** 53-55, Mar.

Presents data obtained during cooperative test program. Temperatures of 100, 110, and 120° F were used.—BLR.

The Progress of Failure in Metals as Traced by Changes in Magnetic and Electrical Properties. Patrick E. Cavanaugh, Cyclograph Services Ltd., Toronto. *ASTM Proc.*, **47,** 639-650 (1947).

The relative changes in magnetic and eddy-current losses during rotating-beam endurance tests were determined for six metals at loads above and below endurance limit. At loads above this limit, easily detectable changes in these losses occur. In certain applications this fact may be used to predict whether a particular part will fail in normal service. There is, however, no possibility of estimating the remaining endurance life by this method. No significant difference in endurance life is produced by increasing the speed of testing, even though the amount of slip in the metal is materially reduced. This method may possibly be useful to estimate the rate of propagation or slip in a metal.

Tests were performed on standard specimens with an Avery rotating-beam fatigue machine. A Du Mont Cyclograph, essentially a very sensitive oscillator, was used to determine and record changes in magnetic and electric properties of the samples. The field in the Cyclograph test coil is of the order of 1 oersted. The test frequency was 5000 cycles.

A bibliography of 27 references is included.—PDA.

A Review of Methods for Non-Destructive Coating Thickness Determination. R. S. Bennett. *J. Sci. Instruments*, **26,** No. 6, 209-15 (1949) June.

Magnetic and inductive meters; calibration. 11 references.—BNF.

Corrosion Testing. A. Wachter and R. S. Treseder. *Chem. Eng. Prog.*, **43,** No. 6, 315-326 (1947).

A review of factors that may influence corrosion, and general considerations for

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planning and evaluating corrosion tests. —MA.

Variation of Standard Electrode Potentials With Temperature. M. H. EVERDELL. *Nature*, **162**, 995-996 (1948) Dec. 25.

Gilbert recently has directed attention to the desirability in corrosion studies of being able to directly compare potentials measured at different temperatures. Presents theoretical analysis which indicates that the potential of the standard hydrogen electrode or any other electrode does vary with temperature.—BLR.

The Effect of Nickel on the Corrosion Resistance of High Purity Magnesium-Base Alloys. J. K. DAVIES. *Magnesium Rev. and Abs.*, **8**, 46-52 (1948) Jan.

Experimental results on corrosion of specimens of three British magnesium alloys (two containing aluminum) to which up to 0.02% nickel has been added are presented. The samples were immersed for two weeks in a 3% sodium chloride solution saturated with magnesium hydroxide—BLR.

Metal Thickness and Corrosion Effects; Inter-Relations With Aluminum and Its Alloys. F. A. CHAMPION. *Met. Ind.*, **74**, 7-9, 13 (1949) Jan. 7.

Corrosion tests usually are made on relatively thin metal. Allowance must therefore be made for this in applying the results of such tests to the greater thicknesses used in service. Data on this effect are tabulated and methods of allowing for differences in thickness are discussed.—BLR.

Rate of the Primary Step of Aluminum Oxidation at Room Temperature at Low Pressures. (In Russian.) N. K. AUDRUSHCHENKO AND P. D. DANKOV. *Doklady Akademii Nauk USSR* (Reports of the Academy of Sciences of the USSR), new ser., **62**, 353-356 (1948) Sept. 21.

The above was studied, using a specially developed method. Data from comparative investigation of the prmary oxidation step for a series of metals indicate a certain basic regularity, according to which the formation, on the surface of the metal, of a one- or two-molecule oxide layer results in basic changes in the properties and behavior of such a layer. Ten references.—BLR.

• Laboratory Methods

Polar-Type Rust Inhibitors; Methods of Testing the Rust-Inhibition Properties of Polar Compounds in Oils. H. R. BAKER, D. T. JONES, AND W. A. ZISMAN. *Ind. & Eng. Chem.*, **41**, 137-144 (1949) Jan.

Theory outlined in a previous paper is used to show that the various methods used emphasize different variables. It is concluded that no single test can suffice for all needs. The turbine-oil rusting test, the static water-drop corrosion test, and the fog-cabinet corrosion test are described and recommended; the latter two being new. Data are given for a number of different types of inhibitors and inhibited fluids. The stability of rust-inhibited fluids is discussed, and present limitations of low-temperature solubility and long-term storage properties are outlined. Need for more research on the colloidal properties of nonaqueous fluids is pointed out. Test specimens were made of 1/32-in. thick cold rolled steel sheet (SAE 10207). Specimen-forming apparatus is illustrated.

Tube Insulation and Corrosion. F. HAGMAN. *Teknisk Tidsskrift*, **78**, 341-345 1948) May 22 (In Swedish). *J. Iron & Steel Inst.*, **169**, Pt. 2, 230 (1948) Oct.

Loss-of-weight corrosion tests were carried out on short lengths of steel tube which were cleaned and insulated with various materials then immersed in water. Further tests were made on specimens insulated and wrapped with felt and other materials. Corrosion rate of unwrapped insulated tubes decreased with time, whereas for wrapped insulated tubes it increased. Tubes insulated with slag wool and cotton wadding corroded more rapidly than those insulated on rock wool and glass wool, and corrosion was greatest on magnesia-insulated tubes.—INCO.

A Simple Form of Accelerated Atmospheric-Corrosion Test. R. ST. J. PRESTON. *J. Iron Steel Inst.*, **169**, No. 3, 286-294 (1948).

A test is described in which specimens are subjected to corrosion in a warm humid atmosphere containing sulphur dioxide. The specimen is suspended in a beaker containing a little water, the bottom of which is heated by a thermostatically controlled electric heating element and the top of which is cooled by a water jacket; this arrangement maintains atmospheric saturation at the top of the beaker at a reasonably constant temperature. The water jacket is unnecessary at the higher working temperature. The beaker is covered by a lid of unplasticized Perspex, ¼ inch thick. If a sulphurous atmosphere is required, sodium sulphite and acid are used or the water is saturated with sulphur dioxide. A wide range of operating temperature is available, but a solution temperature of not less than 45° C is desirable to ensure adequate condensation on the specimen. Results obtained with various steel specimens are presented.—MA.

Method of Testing the Durability of Corrosion-Resistant Coatings of Steel Under Alternating Stresses. (In Russian.) A. N. MITINSKII AND E. S. REINBERG. *Zavodskaya Laboratoriya* (Factory Laboratory), **14**, 1247-1250 (1948) Oct.

Describes a fatigue-test machine applicable to the investigation of the above. Method of testing and results obtained are indicated.—BLR.

CORROSION TYPES AND INFLUENCING FACTORS

• General

Some Factors Influencing the Corrosion Resistance of Aluminium. E. G. WEST. *Metallurgia*, **39**, No. 232, 210-214 (1949) Feb.

Discusses the role of the oxide film; resistance to different forms of corrosion: pitting, intercrystalline attack, general and galvanic corrosion; protective measures. 20 references.—BNF.

Crystal Structure Is Corrosion Factor. *Amer. Foundryman*, **14**, No. 6, 59 (1948).—MA.

The Effect of Wetting: Influence of Non-Attacking Liquids on the Resistance to Fracture of Solid Bodies. CARL BENEDICKS. *Rev. Met.*, **45**, Nos. 1/2, 9-18 (1948).

Presented to the Société Française de Métallurgie. The effect of normally non-corrosive liquids and moist vapor on the breaking stress of a number of materials, including some metals, was investigated. The effect is not always in the direction of lowering the breaking stress; it may actually increase it.—MA.

Do You Know About Fretting Corrosion? E. V. ALBERT. *Diesel Power*, **27**, 38-43 (1949) Mar.

Discussion of nature and causes of fretting corrosion (false brinelling, friction oxidation) in case of antifriction bearings. Precautions recommended to reduce incidence of fretting corrosion. —INCO.

Fretting Corrosion. E. V. ALBERT, Technical & Research Division, Texas Co., New York, N. Y. *Lubrication*, **34**, 25-36 (1948) Mar.

The nature, mechanism, and prevention of fretting corrosion are discussed, particularly from the aspect of lubrication.

Fretting corrosion, also known as false brinelling or friction oxidation, is the particular type of corrosion or oxidation occurring on the contact areas of loaded metal surfaces subject to oscillatory or vibrating motion. Necessary conditions for fretting corrosion to occur are 1) load, 2) motion, even though only of the order of molecular dimensions, and 3) the presence of oxygen, even if only in slightest amounts, such as that dissolved in lubricants or absorbed in the metal. Where steel or iron parts are involved, Fe_2O_3 is undoubtedly a product of fretting corrosion, X-ray diffraction offering fairly positive identification. Electrolytic conditions, such as the presence of an ionized solution and the setting up of an electrolytic circuit, are not required, the oxidation involved being more direct than galvanic corrosion.

Fretting corrosion is mechanical rather than chemical, although opinions disagree on its exact mechanism. Two theories, both emphasizing slipping as the real cause, are proposed; one involves severance of cohesion bonds between the surface molecules leading to high local heat oxidation, the other suggests that successive production and rubbing off of surface oxide films is responsible for the wear. There is ample evidence that the mechanism may proceed either way, depending upon the factors involved.

In antifriction bearings, higher normal pressures result in greater frictional heat and in larger contact areas between the balls or rollers and races. In other machined parts, especially where fretting is due to induced or externally imposed vibrations, an increase of surface pressure may reduce or eliminate the motion and the severity of corrosion.

Fretting corrosion is increased when surfaces are more highly finished. Steel surfaces of the same degree of surface finish exhibit greater corrosion than do two differently finished surfaces under the same conditions. Similarly, surfaces of like materials are more susceptible than those of unlike materials. Stainless steel is one of the most susceptible

materials, and nickel combinations are among the most resistant. Chromium plating on one of the surfaces is sometimes effective in reducing fretting corrosion.

Since there is no single general solution for all fretting problems, elimination or modification of one or both factors mainly responsible, motion and load, seems to be the best approach. Other suggested solutions include 1) elimination or exclusion of oxygen at contact surfaces, though this is frequently impractical or impossible, 2) adequate lubrication or surface coating, e.g., a lead-plate shear coating or graphited lubricating oil, both applied with success in specific cases, 3) use of a plated or treated surface to increase friction and prevent slipping, e.g., by shot peening, 4) including a gasket to absorb motion without metal pick-up or welding, 5) increasing the hardness of one or both surfaces, 6) inducing residual compression stresses at the contact surfaces through shot peening, rolling, nitriding, or carburizing, and 7) increasing motion in the operative region to a degree sufficient to maintain a protective film of lubricant.

Low-viscosity lubricants with high film strength and high-viscosity oils are both effective, although submergence in the former seems to be preferable.

The Season-Cracking of Copper Alloys. A. L. JAMIESON. Metals Handbook, Amer. Soc. Metals, 1948, 231-233.

All copper alloys are susceptible in varying degrees to season-cracking, the mechanism of which is obscure although the factors involved are well understood. Methods of detecting tendencies to season-cracking are described, as well as remedial measures. The chief of the latter consists of controlled heat-treatment to reduce residual stresses; suitable temp. and times for a number of alloys are tabulated.—MA.

Stress Corrosion. J. C. CHASTON, Johnson, Matthey & Co., Ltd., Research Laboratories, Wembley, Eng. *Nature*, **161**, 891-892 (1948) June.

Stress corrosion, also called season cracking, occurs only when susceptible alloys are internally stressed and kept in specific corroding environments. These stressed alloys do not crack indiscriminately in all corroding media; e.g., stressed brass does not crack in nitric acid even though it is attacked and dissolved, but it cracks readily in air containing a mixture of ammonia, water vapor and carbon dioxide. The stressed alloys can be stored indefinitely in a pure atmosphere.

No completely satisfactory explanation for this phenomenon has been presented, but it is suggested that the basic cause may be selective chemical attack at the grain boundaries, localized by a protective film of corrosion product over the faces of the alloy crystals. This film may be protective only when its structure corresponds to the regular structure of the underlying crystals. At the grain boundaries, where the regular structure of the alloy is interrupted, discontinuities in the adhering film can be expected. The effect of stress is considered to be one of widening the cracks first formed, thereby accelerating attack.

Support is given to this theory by the behavior in acidified ferric chloride of alloys composed of 37.5% gold and the remainder copper, silver, and zinc, cold rolled to about 80% reduction in thickness. This alloy cracks in the chloride solution in about 5 min. If, however, a sample protected on one side with wax is immersed so that the exposed surface presses against a small rotating brush, no cracking can be detected after 30 min., although considerable general corrosion occurs. This behavior indicates the removal of a local protective film from the metal surface.—PDA.

Abrasion, Erosion and Corrosion. Progress in the Study of Metal Surfaces. *Chem. Age*, **58**, 207 (1948) Feb. 7.

Abrasion and erosion of metal surfaces have chemical as well as physical aspects, it was pointed out by C. H. Desch before the Chem. Eng. Group of the Soc. Chem. Ind. (n.d.). In final polishing surface flow occurs, forming a chemically reactive surface layer which absorbs foreign atoms as the original crystalline metal could not. Bowden's studies of the stick-slip action of metal surfaces and the significance of the melting point of metal-polishing materials are reviewed. Protective films formed by corrosion, electrolytic polishing, failure caused by internal stresses, and alloy requirements for chemical engineering are also discussed.

Corrosion Prevention—III. G. T. COLGATE. *Met. Ind.*, **74**, No. 9, 167-8 (1949) March 4.

The last of these three articles deals with the occurrence and avoidance of corrosion at soldered and welded joints,

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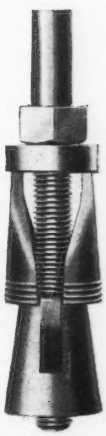

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and that due to the byproducts of moulds growing on non-metallic surfaces close to metals. It is also suggested that when a metal article is to be used under conditions where water may enter it accidentally, provision should be made for drainage to take place freely.—ZDA.

Corrosion Prevention—II. G. T. COLGATE. *Met. Ind.*, **74,** No. 8, 151-3 (1949) Feb. 25.

The second part of this article continues the account of galvanic corrosion and describes methods of protecting necessary joints between dissimilar metals. These comprise the use of insulating gaskets; of sealing compounds (including zinc chromate paints); painting over the joint; coating the joint with a metal which should preferably be anodic to both of the other metals. Zinc and aluminum spraying frequently are used, and the use of chemical or electrochemical treatments to reduce the risk of contact corrosion. The anodizing of aluminum is an example. The interposition of soft material such as a thin coating of aluminum paint, or the elimination of slip by roughening or serrating the faces in contact. Shot peening also may be advantageous. —ALL.

• Factors Biological

Corrosion of Iron and Steel Associated with the Presence of Sulfate-Reducing Bacteria. (Rept. ACC/HI05.1/46) (Great Britain Admiralty, Corrosion Comm., Hull Corrosion Subcomm.); *Prev. Det. Abst,.* **5,** No. 6, Met. 214 (1948).

Anaerobic bacteria were found on steel mine shells in the Malayan waters, growing most rapidly on mines lying on the sea bed. The bacteria developed in cable tanks on shore and in holds of cable ships; they caused serious trouble in the water seal of gas holders and contaminated the gas supply with hydrogen sulfide; they perforated gas and water mains one-half inch thick in seven to nine years, a condition aggravated by the practice of wrapping the pipes with sacking before covering with pitch. Mild steel wire bolster cages used in making causeways were seriously corroded by the bacteria. Ferrous sulfide has been found beneath paint film, and Sporovibrio desulfuricans were isolated from this material. Linseed oil, present in some hull paints, is a good source of food. Little or no work appears to have been done on the relative susceptibility of various steel alloys or on the effect of physical treatment of iron and steel in relation to its corrosion resistance to anaerobic bacteria. Conditions necessary for growth of the sulfate reducing bacteria include an anaerobic environment, presence of inorganic sulfates, and a supply of nutrient organic material. Sulfate-reducing bacteria also have been isolated from a number of species of fouling organisms which presumably act as carriers and as reservoirs of decaying organic nutrient material. (No more information in abstract.)

Influence of Micro-Organisms on the Corrosion of Metals. T. HOWARD ROGERS. *Metaux et Corrosion,* **23,** No. 275/276, 177-183; discussion, 183 (1948). *Cf. J. Inst. Metals,* **75,** 19 (1949).

R. Summarizes work carried out in the laboratories of the British Non-Ferrous Metals Research Association and elsewhere, on the influence of bacteria on the corrosion of metals. Bacteria can affect corrosion in three ways: a) by producing corrosive substances, b) by producing corrosion accelerators, and c) by acting directly on the metal, the corrosion reaction of which forms part of the metabolic cycle of the bacteria. The influence of bacteria on condenser-tube corrosion and on the corrosive power of sea water is discussed. R. distinguishes between three kinds of bacteria: a) sulphate-reducing bacteria; b) sulphur-oxidizing bacteria; and c) bacteria producing carbon dioxide or ammonia. The properties of each group are described. Methods of combating bacterial corrosion are considered. A bibliography of 26 references is appended.—MA.

Microbiological Deterioration of Organic Materials: Its Prevention and Methods of Test. E. ABRAMS. Nat. Bur. Stand. Misc. Publ., No. 188, 41 pp. (1948).

A detailed review of the literature on the microbiological deterioration of org., and fibrous materials (wood, leather, textiles, plastics, lacquers, etc.). A discussion of test methods, and the problems involved in evaluating fungicides is given, and fungicides for various purposes are rated with regard to efficiency. 179 refs.—RPI.

The Isolation and Cultivation of Sulphate-Reducing Bacteria. K. R. BUTLIN, M. E. ADAMS AND M. THOMAS. *J. General Microbiology,* **3,** No. 1, 46-59 (1949) Jan.

A useful paper for bacteriologists investigating the growth of sulphate-reducing bacteria. Indicates the optimum conditions for obtaining pure cultures and maximum growth. Describes morphology of various types of sulphate-reducing bacteria.—BNF.

• Factors Physical and Mechanical

The Effect of Additions on the Stress-Corrosion Resistance of Aluminum-Zinc-Magnesium Alloys Containing 4.5% Zinc and 3.5% Magnesium. W. BUNGART. *Z. Metallkunde,* **39,** 247-253 (1948).

The effect of iron, silicon, manganese, copper, vanadium, iron+vanadium, manganese+vanadium and copper+vanadium were evaluated by 1) alternating stress tests in sea water and 3 sodium chloride solution and 2) endurance limit tests in 3 sodium chloride solution at 70° C, in H_2O-saturated air at 40° C, and in air under normal room temperature conditions. Copper, manganese, manganese+vanadium and copper+vanadium decrease susceptibility to stress corrosion; iron, silicon iron+vanadium and silicon+vanadium have little effect, and vanadium has greater effect than any element studied. Complete data are tabulated.—INCO.

Corrosion Resistance of Powder-Cut Stainless. C. R. BISHOP AND L. E. STARK. Union Carbide & Carbon Res. Labs., Inc. Paper before AWS, Nat. Metal Cong. & Exposition, Philadelphia, Oct., 1948. *Steel,* **123,** No. 16, 200, 202 (1948) Oct. 18.

Discussion of Condition of kerf and heat-affected zones of powder-cut edges in stainless steels, welding of powder-cut beveled edges, and minimizing of heat effects by means of water-quenching applied simultaneously with cutting operation. Zone adjacent to cut face which is chemically altered by powder cutting process is not more than 0.03 inch thick and this zone is removed by superficial grinding. Preparation of beveled plate of unstabilized stainless steels by powder-cutting does not increase severity of heat-affected zone when subsequently welded by manual arc of submerged melt methods.—INCO.

Some Mechano-Chemical Properties of Water. W. A. WEYL AND E. C. MARBOE. *Research,* **2,** No. 1, 19-28 (1949) Jan.

A strong similarity has been found between the atomic structures of water and glass; on this analogy, cavitation is presumed to produce hydrogen and hydroxyl ions which cause corrosion; the effect of foreign substances on cavitation is also discussed.—BNF.

On the Relationship Between Stress and Temperature in Stress-Corrosion. GUNTER WASSERMANN. *Z. Metallkunde,* **39,** No. 3, 66-71 (1948).

Results of stress-corrosion tests, in various corrosive media, on plain and austenitic steels, aluminum and magnesium-base alloys, and brasses, show that a straight-line relationship is obtained when the stress (5-50 kg./mm.²) is plotted against life (in hr.) on a log-log scale; a similar relationship is obtained when temp. (20°-100° C.) is substituted for stress. In both cases work-hardened material shows a smaller endurance and a greater slope towards the axes than does annealed material. In spite of this relationship between stress-corrosion and temp., discretion must be used if elevated temperatures (up to 100° C) are employed to reduce the time of testing. —MA.

High-Temperature Attack of Various Compounds on Four Heat-Resisting Alloys. N.A.C.A. Tech. Note 1731. D. G. MOORE, J. C. RICHMOND AND W. N. HARRISON, Nat'l Bur. Std., Oct. 1948. 6 pp. 8 pp. tables, photographs.

A study of the corrosive reaction of common ceramic coating ingredients with Hastelloy B, S-816, S-590 and Haynes Stellite No. 21 showed that the high-molybdenum alloy, Hastelloy B, was the most susceptible of the four alloys to heavy atack by the more corrosive coating ingredients when heated in air for 17 hours at 1500° F. The most corrosive compounds were the alkalies, lead compounds and some of the alkaline earths. Alkalies did not attack Hastelloy B at 1500° F in atmospheres of carbon dioxide or helium, indicating that reaction is not with the alloy itself but with the oxide film formed by heating the alloy in air.

The Effect of Addition Elements on the Oxidation of Nickel and Chromium-Nickel Alloys. L. HORN. *Z. Metallkunde,* **40,** 73-77 (1949).

Additions of beryllium, calcium, aluminum, silicon, titanium, zirconium, cobalt, thorium, chromium, molybdenum, tungsten, manganese, copper and gold to nickel and of titanium, columbium, zirconium, tantalum, cerium and calcium to chromium-nickel alloys are considered.

Resistance to oxidation is increased in proportion to the atomic radius of the added metal as well as by the nature of the oxide formed and the rapidity of its formation.—INCO.

Quantitative Evaluation of Intergranular Corrosion of 18-8 Titanium Steel. FREEMAN J. PHILLIPS. *Trans. ASM*, **39**, 891-941 (1947).

A quantitative method has been developed for predicting intergranular corrosion of 18-8 titanium steel under given set of conditions. The method is based on microstructure and chemical composition and it may possibly be applied to other grades of stainless steels.

Titanium or columbium is added to stainless steels in a minimum amount of four and eight times the carbon content, respectively, to prevent intergranular corrosion. Such an addition ties up the carbon as a stable titanium or columbium carbide. The additive must adequately combine with the carbon before the material is subjected to subsequent sensitizing temperatures because the carbon in excess of the solid solubility limit then will precipitate as chromium carbide. Such a precipitation produces a material potentially subject to intergranular corrosion.

The basic work for this study was made on 18-8 titanium steel. All embrittlement test failures could be attributed to an insufficient combination of carbon with titanium. The amount of titanium carbide present could not be explained by the results of many embrittlement tests. A definite relationship was found between the chromium content of the steel and the amount of free

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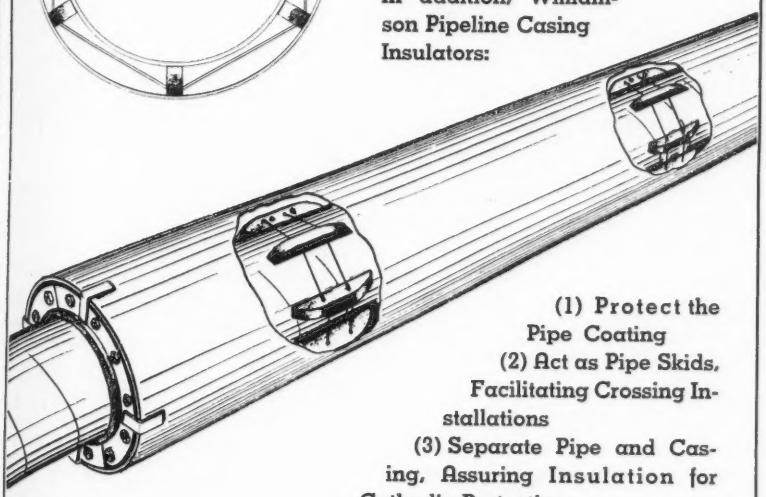

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carbon per inch of grain boundary perimeter. This free carbon is defined as the total carbon of the steel minus the amount combined with the titanium and is, therefore, the amount of carbon free to combine with the chromium during sensitization.

When values for chromium content were plotted against values obtained from the embrittlement tests for free carbon per inch of grain boundary per square inch of structure, samples with satisfactory behavior could be divided from unsatisfactory ones by a straight line. A mathematical treatment of the data shows that before embrittlement can be predicted the amount of carbon combined with titanium must be considered in its relationship to both grain size and composition. The relationship which was found permits rationalization of hitherto unexplainable failures in the embrittlement test of 18-8 titanium steel having the specified titanium/carbon ratio. The influence of grain size on the intergranular corrosion of 18-8 appears to be explained by a lessening of the chromium carbide concentration at the grain boundaries of a fine-grain steel; with decreasing grain size, the grain boundary area increases and presents a greater region over which a given amount of precipitating chromium carbide must be distributed. This effect is most pronounced in relatively short sensitizing treatments. A limited amount of intergranular chromium carbide precipitation can occur without causing failure.

The formula which was derived may be somewhat cumbersome to handle in its present form in routine work, but standard tables can be computed which give the limiting free carbon content for any grain size and chromium content. It is believed that the results can be applied to 18-8 columbium or even plain 18-8 because the method can be used to compute the permissible maximum free carbon, irrespective of the presence of stabilizing elements. Comparison of this maximum with the actual free carbon should indicate the expected behavior.—PDA.

Propeller Characteristics Under Non-Axial Flow. COMMANDER C. R. HIRSCHBERGER, U.S.N. AND COMMANDER F. C. JONES, U.S.N. *J. of the Amer. Soc. of Naval Eng.*, **60,** 461-472 (1948) Nov.

This article is accompanied by photographs which demonstrate that cavitation of a screw propeller under non-axial flow varies with blade position and does not remain the same as the blade makes its complete revolution. Therefore, in addition to the generally accepted conditions, the degree of cavitation depends on blade position when the entering flow-lines are not parallel to the propeller axis. The investigation conducted as a result of this observation showed that cavitation occurs earlier (at lower slip) under non-axial flow. Since propeller characteristics are often determined from propeller tunnel tests the discrepancy between predicted and actual starts of cavitation has been a source of concern to propeller and ship designers. A further manifestation of the fundamental nature of this phenomenon has been the disparity between the power absorbed by each propeller of a twin screw vessel having different shaft declivities and therefore different angularity between flow lines and propeller axis. After the observation of the varying degrees of cavitation with blade position, the investigation was diverted to an analysis of this cavitation phenomenon. It was determined that the reason for the varying degree of cavitation as the blade rotated was the varying angle of attack between the blade section and the entering flow lines.—TIME.

Erosion-Corrosion of Metals and Alloys. M. G. FONTANA AND W. A. LUCE. *Corrosion,* **5,** No. 6, 189-193 (1949) June.

The accelerated deterioration of metals and alloys under the combined effect of corrosion and erosion is due to the continuous mechanical removal of the protective layer of passive materials which develop as the result of the chemical reaction between metal and corrosive medium. The reproduction of conditions encountered in practice is important in the choice of materials and design and led to the development of a testing apparatus consisting of a 30-gal. glass-lined tank, neoprene hoses, a Chlorimet 3 pump, a nonmetallic housing for the erosion-corrosion specimen, and auxiliary equipment. The type of test made possible with this equipment is reliable for predicting actual service-behavior of ferrous and nonferrous metals. 8 illustrations.—TDD.

The Stress-Corrosion of Aluminum Alloys. E. H. DIX, JR., AND R. H. BROWN. Metals Handbook, Amer. Soc. Metals, 1948, 228-231.

The stress, electrochemical, environmental, and other factors involved in stress-corrosion are described, and the susceptibility or otherwise of aluminum alloys is discussed type by type. The stress required to cause stress-corrosion is high (one-half to three-quarters of the yield strength), and residual stresses are more likely to be the cause than service stresses. Pure aluminum, aluminum casting alloys, lower-strength non-heat-treatable and Mg_2Si-type heat-treatable wrought alloys are not prone to stress-corrosion.—MA.

The Stress-Corrosion of Magnesium Alloys. M. A. HUNTER. Metals Handbook, Amer. Soc. Metals, 1948, 234-237.

Service failures due to stres-corrosion have not been reported in any magnesium casting alloy or in the wrought alloy M1 (1.5% manganese), but the alloy AZ61X (6.5% aluminum, 1% zinc) can be extremely susceptible in certain physical conditions. Alloy AZ31X (3% aluminum, 1% zinc) is less sensitive than AZ61X, but not immune under all conditions. Improvement can be effected by suitable heat-treatment, and liability to stress-corrosion does not limit the structural applications of magnesium alloys. —MA.

Concerning Intercrystalline Corrosion of Low-Alloy Steels in Nitrate Solutions. E. HERZOG. *Metaux & Corrosion,* **24,** 29-42; Disc. 42-44 (1949) Feb. (In French.)

The above was investigated for steels containing 2.3% chromium and 0.8% aluminum as max. amounts, in the form of castings, rolled sheets and welds. Influence of heat treatment, cold working, and decarburization and resulting crystalline structure were determined. Explains mechanism of intercrystalline corrosion. Data are tabulated and charted. 21 references.—INCO.

High Temperature Corrosion of Metals. A. DRAVNIEKS AND H. J. MCDONALD, Ill. Inst. Tech., Paper before NACE, Ann. Conf., Cincinnati, Apr. 11-14, 1949. *Corrosion,* **5,** No. 7, 227-233 (1949) July.

Discussion of experimental work under sponsorship of Office of Naval Research on reactions of gases with metals at high temperature includes forms of attack, scaling growth laws, adherence of scale to metal, thermal expansion and other characteristics of scale formation. Accepted theories which endeavor to explain scale reaction, courses and rates and application of these to practical problems are reviewed as well as effect of temperature variations, pressure, foreign components in gas phase, surface conditions, and rate of flow on the course of the reaction. 52 references.—INCO.

Corrosion and Mechanical Wear. (In German). ERICH GEROLD. *Metalloberflache,* **3,** 29-32 (1949) Feb.

Describes and illustrates reciprocal effects of the above in steels. Data are tabulated.—BLR.

Effect of Additions of the Oxidation of Nickel and Chromium-Nickel Alloys. L. HORN. *Zeit. Metallkunde,* **40,** 73-76 (1949) Feb.

Effect of numerous elements on behavior of nickel at 900° C and of chromium-nickel at 1200° C, was studied. Effect produced depends on the way in which the foreign element fits into the crystal lattice of the material to which it is added. Effect increases with difference in atomic radius between it and the nickel or chromium-nickel alloy. In nickel the fitting of a second element into the lattice reduces the oxidation resistance. In chromium-nickel alloys a third element increases rate of diffusion of chromium atoms, and causes rapid formation of a protective layer of chromium oxide, which is the basis of the oxidation-resisting characteristics of these alloys. —INCO.

• Factors Metallurgical

Thermal Treatment of Aluminum Alloys. E. H. DIX, JR. ASM, "Physical Metallurgy of Aluminum Alloys," 1949, p. 200-240.

Summarizes objectives; describes terms; and discusses treatments under the following headings: annealing, recovery, preheating, solution heat treatment, quenching, aging and reheating. Also considers effects of thermal treatment on corrosion resistance and presents an explanation of the Alco temper designation for cast and wrought products. 36 ref.—BLR.

Non-Corrosive Soldering Flux for Universal Application. DANIEL RODIER, JOHN A. DEROSA; Foster D. Snell, Inc., New York and Chester A. Snell. (Report No. 8; U. S. Dept. of the Army, Contract No. W36-039-se-32296) (1948) June.

Summary Report

A very active, noncorrosive flux for bright and slightly oxidized copper, brass, and tin plate consists of an alcoholic solution of 25% Teglac-128 resin, 1% ethylhexadecyldimethylammonium bromide, 1.2% glycerol, and 10% amyl acetate. An aqueous flux, made up of

hydrated tin tetrachloride, triethanolamine, and a wetting agent, is useful for soldering the above metals and stainless steel but is markedly corrosive. A number of flux pastes containing tin tetrachloride, triethanolamine, and amylphosphoric acids in vehicles of lanolin, petroleum jelly, and Alox Compound 325 are useful for stainless steel but are not recommended because of their corrosiveness.

Five representative fluxes containing rosin and Teglac-128 resin and one flux containing Alox Compound 325 monoamyl acid phosphate are fungus resistant in their residual states; in their raw states, however, all but a paste flux sample support mold growth.

A new test for evaluating flux corrosiveness, namely, the electrical conductivity of flux solutions, gave results which correlated only roughly with water-extract conductivity data. In the corrosion-current test, good correlation of current and intensity of accelerated corrosion with other exposure data was obtained when a glass rod was used as flux carrier along with a specially designed specimen holder and a guarded testing circuit at 100% relative humidity plus dew and about 30° C.

Mildew resistance was tested according to specification JAN-C-173 (Coating materials, moisture- and fungus-resistant, for the treatment of communications, electronic, and associated electrical equipment) using *Aspergillus niger, A. flavus, Penicillium lutem; Trichoderma*-T-1-USDA, and *Chaetomium globosum* as test fungi. Although no attempt was made to increase the inhibitory power of the resin fluxes, small amounts of certain fungicides such as trioxmethylene (trioxane),

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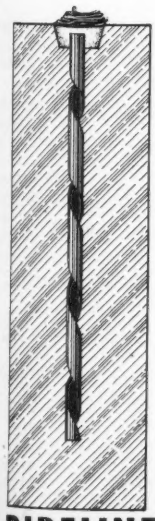

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tricresyl phosphate, and the Dowicides might be added without impairing their fluxing properties.

PDC Comment: This summary report is the eighth in a series of progress reports on file at the Center. The first report of the series provides theoretical and bibliographical background, in it are surveyed the classification of metal joining processes, the problem of surface cleanliness in soldering, the mechanism of bonding by solder and that of flux action, materials used as soldering fluxes, and methods of testing flux efficiency. The bibliography lists 194 original journal articles and 247 American and British patents.—PDA.

Corrosion Resistance of Powder-Cut Stainless Steels. L. E. STARK AND C. R. BISHOP, Union Carbide & Carbon Res. Labs. Paper before AWS, Ann. Mtg., Philadelphia, Oct. 24-29, 1948. *Welding J.*, **28,** No. 3, 104s-105s (1949) Mar.

Heat affected zone of powder-cut edges may be eliminated by using stabilized or extra-low-carbon stainless steels or by annealing powder-cut unstabilized stainless steels. Powder cutting produces a heat affected zone underlying powder-cut surface only in unstabilized steels. Full corrosion resistance is restored by a proper annealing heat treatment or by removing some metal from cut edge of plates. Corrosion resistance of stabilized stainless steels is unimpaired by powder cutting. When powder cutting is used to form metal and no further treatment is to be applied, heat effect can be minimized or eliminated by means of a supplementary water quench accompanying cutting or by use of certain steels such as Types 347 or 304. Electron micrographs and tables are included.—INCO.

Corrosion-Resistant Steels. A. J. ZUITHOFF. *Ingenieur*, **60,** No. 12, mk 27-28 (1948). *Brit. Abs.*, **BI,** 488 (1948) Sept.

Steel containing 12-14 chromium may be hardened and is fairly rust-resistant. 16-30 chromium may cause hardening because chromium narrows austenitic range, but such alloys are more workable than 18-8 chromium-nickel steel. In 18-8, carbides draw their carbon from whole crystal, but their chromium form outer zone alone, hence intercrystalline corrosion may occur with risk of unsuspected fracture. Addition of 2-4% manganese improves resistance to acids and increases strength at high temperatures. Addition of 2% silicon has little effect on corrosion resistance, except in respect of hydrogen chloride. Nitrogen increases strength, tenacity and creep limit. Alloys with manganese are finding favor as a substitute for nickel, those with higher chromium and nickel show improved resistance to oxidation and mechanical strength at high temperatures and those containing cobalt (Vitallium) and nickel (Hastelloy) show great strength at high temperatures and good resistance to chemical attack.—INCO.

CORROSIVE ENVIRONMENTS

• General

Formation of Photographically Active Particles during Atmospheric Corrosion of Metals. I. L. Roikh. *Doklady Akad. Nauk*, U.S.S.R., **63,** No. 2, 119-122 (1948) Nov. 11. (In Russian).

The atmospheric corrosion of aluminum, magnesium and zinc over periods to 10 days was investigated by placing the metals, as filings, 1 mm. away from a photosensitive surface. The optical density of the image obtained was then measured.—BNF.

• Chemicals Inorganic

The Effect of Concentrated Nitric Acid on Ferro-Silicon Coated Steel. F. ERDMANN-JESNITZER. *Metall.*, No. 15/16, 264-265 (1948) Aug. (In German.)

Although an iron-silicon coating on steel has good adhesion, it does not protect the steel against corrosion by concentrated nitric acid at room temperature. The attack follows the grain boundaries of the coating and penetrates only slightly into the steel.—BNF.

Corrosion by Sulphates. W. Z. FRIEND. *Chem. Eng.*, **55,** No. 11, 145-147 (1948) Nov.

Gives corrosion rates under plant conditions for nickel, Monel, Inconel, Hastelloy, chemical lead, cast iron, steel, etc., in solutions of ammonium sulphate, aluminum sulphate, non-oxidizing and oxidizing acid sulphates.

Resistance of Wood to Corrosion by Hot Chemicals. D. NARAYANAMURTI & V. RANGANATHAN. Indian Forest Leaflet, No. 101. *Brit. Chem. Digest*, **3,** Nos. 180-181 (1949) Mar.

Description of results of experiments on resistance of cypress to hot chemicals and effect of various treatments to prevent corrosion of wood by hot chemicals. Chemical solutions were water, 5% and 10% sulfuric acid, 5% and 10% hydrochloric acid, and 2% and 5% sodium hydroxide. Protective materials were Bitumex paint, creosote, cashew nut shell oil, cashew nut shell oil paint, and phenol-formaldehyde resin. Results of strength tests are shown and summarized in tables. If strengths of water-soaked controls for treatments are compared, best results are given by cashew nut shell oil and phenol-formaldehyde. If strengths are considered as percentage of untreated controls, phenol-formaldehyde proved best.—INCO.

Catalytic Oxidation of Sulphur Dioxide on Metal Surfaces. G. TOLLEY. *J. Soc. Chem. Ind.*, **67,** Nos. 10, 11, 369-373, 401-404 (1948) Oct., Nov.

Part I gives the rates of catalytic oxidation on surfaces of mild steel, aluminum sprayed steel, and aluminized steel (sprayed with cadmuim-aluminum alloy, followed by heat treatment at 850°). Part II presents further data on the reaction at a steel surface, and includes an appendix on the microscopical examination of scale.—BNF.

• Chemicals Organic

The Action of Nitrosyl Chloride on Some Metals and Their Compounds. J. R. PARTINGTON AND A. L. WHYNES. *J. Chem. Soc.*, **1948,** 1952-1958, Nov.

The action of nitrosyl chloride on aluminum, gallium, indium, thallium, some of their halides, and thallous nitrate and nitrite was investigated.—MA.

Contribution a l'etude de la Corrosion des Metaux par les Carburants. (Contribution to the Study of the Corrosion of Metals by Carburizing Fuels). P. SCHLAPFER AND A. BUKOWIECKI. *Metaux et Corrosion* (France), **23,** No. 280, 267-77 (1948) Dec.

The fuels examined were various alcohols, acetone, ethyl acetate and petrol. They were tested individually and in mixtures; in each case the effect of added traces of water was determined. The metals tested were iron, aluminum, zinc, lead, copper and a magnesium alloy. Samples of the metals were immersed in the liquids at 30° C for a week. In general, it was found that water-free fuels had only a weakly corrosive action, even though acidified. Where water had been added, however, rather thick films were found on the metal surfaces.—ZDA.

Corrosion des Metaux par les Liquides Organiques. (Corrosion of Metals by Organic Liquids). R. DUBRISAY. *Metaux et Corrosion* (France), **23,** No. 280, 278-84 (1948) Dec.

This paper reports the start of a detailed study of the corrosion of metals by organic liquids. The first part deals with the action of fatty acids dissolved in organic solvents on copper, aluminum, tin, nickel and cadmium. The last is attacked only when oxygen and water are both present. The second part describes the action of carbon tetrachloride and chloroform on various metals, with particular reference to the mechanism of the attack on zinc. In the absence of moisture this attack is very slight. The third part describes the interaction of metals with methanol. In the absence of water, zinc gives a basic formate; with water present, a neutral hydrated formate is found.—ZDA.

Corrosion. Hydroabietyl Alcohol. *Int. Chemical Eng. and Proc. Ind.*, **30,** No. 3, 112-113 (1949) Mar.

Hydroabietyl alcohol, an intermediate manufactured by the hydrogenolysis of Abalyn, a rosin ester, has been developed on a commercial scale. Constructional materials used in the plant are as follows: up to the feed pumps black iron is used; thereafter and as far as the low pressure separator, stainless steel is employed, but as this is liable to cause discoloration or contamination of the product, aluminum pipes, etc., are installed beyond this point.—INCO.

• Soil

Corrosion of Metals; the Influence of Micro-Organisms. T. HOWARD ROGERS. *Met. Ind.*, **73,** No. 21, 22, 403-405, 432-433 (1948) Nov. 19, 26.

An account based on published literature of some of the ways in which corrosive attack can be brought about through the influence of bacterial action. This paper was presented to the Journées sur la Corrosion des Métaux, in Paris, Oct., 1947, and published in French in *Metaux et Corrosion*, **23,** No. 275-276, 177-183 (1948) July-Aug. A detailed account of

some of the investigations of the B.N.F. M.R.A. in this field appeared in *J. Inst. Metals*, **75**, No. 1, 19-37 (1948) Sept. It is pointed out that while any bacteria which are capable of forming a colony in close proximity of a metal surface may be responsible for corrosion of the metal, three specific groups of bacteria are known to produce effects which are sharply defined and well understood. Sulphate-reducing bacteria cause anaerobic corrosion of iron, as well as of nonferrous metals by performing the action of a depolarizer in removing and oxidizing cathodic hydrogen. Sulfur oxidizing bacteria, while of less importance than the former group, give rise to the evolution of sulphuric acid. Bacteria producing carbon dioxide or ammonia as a result of their normal metabolism accelerate corrosion in both salt and fresh water. The most effective methods of combating bacterial corrosion consist in the use of dyes, where the system is not too large, or else in the application of corrosion-resistant alloys. Twenty-six references.

Environment pH as a Factor in Control of Anaerobic Bacterial Corrosion. J. B. Hunter, H. F. McConomy and R. F. Weston. Presented A.P.I. Mtg., Chicago, Nov. 1948. *Corrosion*, **4**, 567-580 (1948) Dec.; discussion, 580-581.

Presents experimental data on the effect of alkalinity on sulfate-reducing bacteria. Two problems were studied: type of action of pH's over 9.0 (bactericidal or bacteriostatic); and possibility of growth recurrence after exposure at high pH. The action was found to be bacteriostatic; that is, growth recurred after the pH was lowered. Photographs of test panels illustrate the results.—BLR.

Pipe Corrosion Mitigation Practice. A. H. Cramer, Michigan Consolidated Gas Co. Paper, AGA, Distribution Motor Vehicle and Corrosion Conference, Pittsburgh, April 19-21, 1948; *Am. Gas J.*, **168**, No. 6, 23-7, 58 (1948) June.

Underground pipe protection practices of the Michigan Consolidated Gas Co. are detailed and their experiences with the Pearson Pipe Coating Fault Locator are summarized. The pipe is coated with a hot wax base coating and wrapped with successive dielectric layers of asbestos, cellulose acetate, tobacco cloth and kraft paper using a special described machine. Insulating couplings such as Formica

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brushings and Saran nipples installed in compression couplings are used to prevent the propagation of stray currents between protected and unprotected sections of pipe and are also installed at intervals between the protected sections. Test wire stations are installed at 2000-4000 foot intervals. The Cadwell Thermit weld method is used to join the test wires to the pipe. Electrolysis surveys are made once a year by current flow measurements using the Pipe Coating Fault locator of J. E. Pearson (Sun Oil Co.) with some described modifications. The hummer of the locator is applied to the test wire and leakage currents are detected from the ground via cleats, lead wires, amplifier and earphones. The device locatd 783 coating faults in 350 miles of pipe in four years' service. An analysis of the kinds and causes of the faults is included.

An Investigation of the Corrosive Effects of Soils on Steel Plates. G. D. GEMMELL. *New Zealand Eng.*, **3,** 468-469 (1948) May 10. *J. Iron & Steel Inst.*, **160,** Pt. 2, 235 (1948) Oct.

In 1943 Corrosion Committee of New Zealand Institution of Engineers arranged for sets of 12 mild steel specimens to be buried at different places in New Zealand. Plates buried at Auckland, Wellington, and Christ Church were exhumed and this report presents data on nature of soil and loss in weight.—INCO.

Corrosion of Underground Power Sheaths. L. F. GREVE. *Corrosion*, **4,** 529-540 (1948) Nov.; discussion 541-544.

Several methods emloyed by a large utility company for mitigating extremely troublesome corrosive conditions caused by local, concentration, and galvanic cells are described. Includes several diagrams and graphs.—BLR.

• Water

pH Control Through Use of a Sulfur Burner. R. C. ULMER AND J. F. CHURCHILL, E. F. Drew & Co., Inc. *Oil Gas J.*, **47,** No. 30, 111 (1948) Nov. 25.

Provided that the pH of the water is in the proper range, scale and deposits in cooling-water systems can be controlled by treating with complex phosphates which partially prevent the precipitation of materials from the water, together with certain organic materials which render any precipitates non-adherent.

Where the pH of the water is too high for complete chemical protection against deposits, the use of a sulfur burner has been found effective and economical for reducing pH. The equipment consists of a sulfur burner for generating sulfur dioxide and an absorption tower for dissolving this gas in the cooling water. With this method, the cost of reducing the alkalinity of a million pounds of water one part per million costs about 0.29 cents compared with about 1.6 cents using sulfuric acid.—NALCO.

Industrial Water Systems. *Southern Power & Ind.*, **66,** No. 10, 96 (1948) Oct.

Ten case studies show how various industrial water problems have been solved in specific instances. Among the cases presented are:

Condenser water pH control using a Beckman pH meter and a Bristol air-controlled valve eliminated corrosion and emulsification in the system.

Algae eliminated in an ammonia condenser system by using dry HTH.

Sludge contact hot process operation and results with a Liquon unit.

High silica water corrected for boiler feedwater use by E. F. Drew and Co. treatment and control at a large Arkansas lumber company plant.

Softener capacity boosted by installation of Elgin "Double-Check" manifold system in a zeolite softener to permit a deeper bed of zeolite to be utilized.

pH control avoids stream pollution through use of Leeds and Northrup Micromax pH recording controller and glass pH electrode system for controlling soda ash feed to acid wastes.

Corrosion checked in hot water system with Brown-Electro Company's electrolytic devices installed in hot water generators.

Condenser corrosion stopped through use of National Aluminate Corporation's No. 38 treatment consisting of a blend of polyphosphates.

Corrosion in steam lines prevented by using Elgin Softener Corporation's "Elgex" chemical treatment at a Southern power plant.—NALCO.

The Experimental Basis for the Determination and Calculation of the Aggressive Properties of Natural Waters. (German.) H. SCHMASSMANN. *Schweiz. Arch. Angew. Wiss. u. Tech.*, **14,** No. 7, 206-213 (1948) July.

Summarizes the methods for determining free carbon dioxide, alkalinity, and hardness; magnesium, lime and sulphate contents, and gives results obtained for various waters. Fourteen references.—BNF.

Solving the Diesel Water Problem on a Northern Line. *Ry. Eng. and Maintenance*, **44,** No. 12, 1286 (1948) Dec.

Described in this article are the methods developed by the Northern Pacific to provide properly treated water for their Diesel engine steam generators. Initial treatment at their various watering stations consists of acid or sodium zeolite softening, lime-soda ash softening, or wayside treatment consisting of phosphate and alkaline materials. Excellent protection against both scale formation and corrosion has been achieved by post-treatment consisting of a blend of alkaline polyphosphates and specially processed organic material which has high oxygen absorptive properties. Most of the generator coils are 18 months old and the maximum tube life with this treatment is still undetermined.

Diesel cooling water is treated with chromate-type inhibitors.—NALCO.

Questions and Answers—Electrolytic Action in this Boiler? M. PERSINGER. *Power Generation*, **52,** No. 5, 80 (1948) May.

Many cases of corrosion attributed to electric action are really due to oxygen and acid. Views on how to combat this particular case of corrosion.—INCO.

Vergleichende Korrosionsversuche in Verschiedened Seewassersprühanlagen. II (Comparative Corrosion Experiments in Various Sea Water Spraying Installations. II) SCHONHERR, Vereinigte Aluminium-Werke A.G., Lautawerk, Ger. Office of Technical Services, PB-70015, Frames 1308-1329 (1938) July.

The type and degree of corrosion of unplated Duralumin strips were tested in eight different sea water spraying chambers. Tensile tests of all samples were carried out on one machine. Corrosion results varied widely. To obtain comparable values from different laboratories it is advisable to use test conditions which will result in a decrease in strength of about 10%. For alloys which do not corrode readily, such as plated aluminum-copper-magnesium or copper-containing alloys, the attack must be prolonged or aggravated, e.g., by increasing the amount of spray per unit volume per hour.

Each spraying chamber may be classified into one of three groups depending on whether it causes a decrease of tensile strength larger than, equal to, or smaller than 10% after 12 weeks and a decrease of elongation of less than 50, 50-60, or 70-90%, respectively. Within each group a difference in the physical appearance of the samples may be caused by various factors; e.g., samples suspended by a hook or wire show stronger corrosion along the center line which serves as a path for the drops.

The corrosion of cut edges apparently is increased when the intervals between sprayings are neither too long nor too short and when numerous spraying cycles are applied. Strong edge corrosion of comparable degree was observed in three different chambers having one 10-minute spraying period per hour.

PDC Comment: The dependence of the results of accelerated spraying tests upon the characteristics of individual spray chambers is discussed in another report from the same source. (Report on Systematic Experiments with Spraying Apparatus of Varying Size and Structure, Including a Comparison of their Behavior in Dipping Apparatus. Office of Technical Services, PB-70191, Frames 3456-3460 (1942). PDA 5: Met 186, C-551).—DPA.

Question-Answer Effect of Zero Soft Water on Boilers. *Marine Eng. & Shipping Rev.*, **53,** No. 6, 78 (1948) June.

Boilers corrode when zero soft water is used because of the dissolved oxygen. Hard water deposits a scale which is protection against rust, especially in new boiler. When water with zero hardness is used, it is deaerated with an open heater. Where not practical, internal treatment with a material to react with oxygen is used.—INCO.

Internal Treatment with Magnesium Chloride in Absence of Phosphate. F. H. LONG AND W. A. POLLOCK, Wisconsin Electric Power Company. (A paper presented at ASME Semi-Annual Meeting, May 30-June 4, 1948, at Milwaukee, Wis.) *Combustion*, 47 (1948) Aug.

Continuous feeding of magnesium chloride in the absence of phosphate has reduced silica carryover from the 1400 psi, 375,000 pound-per-hour boiler at the Commerce Street Station in Milwaukee, according to the experiences related by the authors of this paper. Organic treatment apparently is helpful in reducing chip scale formation in the boiler.

Feedwater is softened with hydrogen zeolite, followed by degasification and pH adjustment with caustic.—NALCO.

Factors Influencing Boiler Corrosion. V. V. KENDALL, National Tube Co. Paper, 51st Annual Meet. ASTM, Panel Discussion on Corrosion of Pressure Vessels, Detroit, June 21-5, 1948; abstr. *ASTM Bull.* No. 152, 25 (1948) May.

The factors influencing boiler corro-

sion are gases such as oxygen, carbon dioxide, hydrogen, etc., corrosive effects of boiler water substances, galvanic effect of dissimilar metals, velocity, temperature, and pressure. Available data on the solubility of the various gases from condenser vacuum to boiler pressure are summarized. A review and tabulation is given of the rates of corrosion of nonferrous and ferrous metals used in power systems, the compounds likely to be formed from the various nonferrous metals and their subsequent deposition in other parts of the system, and the galvanic effects of carbon and alloy steels on nonferrous metals. (No more information in abstract.)

Preventing Corrosion of Condensate Return Lines. R. T. HANLON, National Aluminate Corp. Paper before 10th Ann. Midwest Power Conf., Chicago, April 1948; *Combustion*, **19**, No. 10, 38 (1948) Apr.; *Heating, Piping Air Cond.*, **20**, No. 5, 86-88 (1948) May.

Corrosion of steel due to carbon dioxide and oxygen in condensate recognized. Reduction of carbon dioxide reduces corrosion. Sources of CO_2 are water with high calcium, magnesium, or sodium bicarbonate high makeup to boiler plant of water with low calcium, magnesium, or sodium bicarbonate, lack of deaerator where needed, improper treatment of boiler water, and improper makeup water pretreatment. Exchange materials of carbonaceous nature permits design of softening carbon dioxide removal systems using acid and brine for regeneration of materials. Suggestions on how to reduce carbon dioxide and oxygen without special equipment. Alkaline substances neutralize corrosive tendencies of condensate. Amines treat return condensate but not recommended for boiler pressures above 300 psi. Polyphosphates used where amines not feasible. Four references.—INCO.

Prevention of Scale Formation and Corrosion in Water Supply Systems. Anon. *Fuel Econ. Rev.*, **27**, 43-47 (1948).

Article describes the value of treating waters with hexametaphosphate to minimize building-up of scale and to reduce corrosion. Practical ways of making the addition are described.—BNF.

Intercrystalline and Other Types of Corrosion of Steam Boilers. R. E. COUGHLAN AND OTHERS. *Am. Railway Eng. Assoc. Bull.*, **50**, 167-169 (1948) Nov.

Presents committee report on the above. Use of sodium nitrate as an inhibitor is recommended. Describes and diagrams simple device used to detect embrittlement.—BLR.

Corrosion of High-Pressure Steam Generators: Status of Our Knowledge of the Effect of Copper and Iron Oxide Deposits in Steam Generating Tubes. R. C. COREY, Bureau of Mines. Paper, 51st Ann. Meet. ASTM, Panel Discussion on Corrosion of Pressure Vessels, Detroit, June 21-5, 1948; abstract, *ASTM Bull.* No. 152, 25 (1948) May.

Published information on copper and iron oxide in boilers is reviewed critically and correlated with the writer's personal experiences with the problem, and with theoretical data available. Numerous cases of severe, pit-type, internal corrosion in high-pressure steam generators, principally of furnace wall tubes, have been ascribed to deposits consisting of Fe_3O_4 and copper and its oxides. However, this is only a speculative theory. (No more information in abstract.)

A Study of Tube Corrosion in the Marine and Power Fields. Chase Brass and Copper Co., Conn. 31 p.

Information is presented relative to the behavior of condenser tubes under various operating conditions, discussions being directed to the topic of corrosion. Corrosion discussions include: types of water; corrosion outline — causes and forms; destructive cavitation; galvanic action; intercrystalline corrosion and dezincification. An outline of methods of manufacturing tubes is also included, together with useful charts, specifications, installation data, surface area, and physical properties.

The Treatment of Soft Waters. (In French.) O. L. BIHET AND H. GOLDSTEIN. *Metaux & Corrosion*, **23**, No. 271-272, 103-107 (1948) Mar.-Apr.

Deals with treatment of a soft, very acid water. Manganese and iron were removed by flocculation with ferric sulphate at various pH values under oxidizing conditions (chlorine) and water was treated with lime and hexametaphosphate. Corrosivity tests were carried out using soft iron wire as test-pieces.—BNF.

Corrosion Can Be Controlled in Refrigeration Systems. J. I. MONTEX. Paper, N. J. Sec. Am. Soc. Refrig. Eng. (1948) Mar. 11; *Refrig. Eng.*, **56**, No. 1, 35-8 (1948) July.

In refrigerating systems, dissolved carbon dioxide, oxygen, sulfur dioxide and hydrogen sulfide, as well as low pH (oxygen is more corrosive in an acid environment), dissimilar metals in contact, and high temperature all contribute to the corrosion of metallic parts. The acid attack of water with a pH under 6 can be more severe than the oxygen corrosion. Sodium hydroxide and sodium chromate neutralize the acidity, raise the pH and inhibit corrosion; satisfactory

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range is pH of 7.5 to 9.5 and sodium chromate concentration of 250 to 1000 ppm. Chromates are toxic and irritant and contact with skin should be avoided. Polyphosphates also may be added to water systems to react with scale, forming salts which can be removed by blow-down. Sodium hydroxide and sodium chromate also are used to inhibit corrosion in brine systems (pH of 7.5 to 9.5) sodium chromate concentration of 2000 ppm or more in a calcium chloride brine, and 4000 ppm in a sodium chloride brine are recommended.

Softening Cooling Water for Diesel. L. E. MADSEN, Superintendent of Power, North Branch, Minnesota. Plant Eng. 32 (1948) July.

Thick scale formed in the Diesel engine cooling water system at this power station when using water of 16 gpg hardness for make-up. A slowly-soluble glassy phosphate fed to the water at the rate of about 5 ppm was successful in retarding scale-formation.—NALCO.

Experiences in Conditioning Corrosive Army Water Supplies in New England. G. P. LOSCHIAVO. Paper before NACE Ann. mtg., Chicago, Apr. 7-10 (1947). *Corrosion,* **4,** No. 1, 1-14 (1948) Jan.

Types of water found in New England army area are highly corrosive soft surface water, highly corrosive soft well water, and high iron-containing water. Treatment for the well water included lime slurry and for the iron-containing water, hexametaphosphate. Nine installations were established in the Boston army area, which was supplied by the surface water, to compare various chemicals; six involved galvanized steel loops in chemically treated water, two used galvanized steel loops in untreated water and one used phenolic resin-baked loop in untreated water. Results not yet available. Illustrations.—INCO.

Dezincification. I. — "Plug" and "Layer" Types of Attack—Susceptible Alloys. II.—Consideration of Internal and External Influencing Factors. III.—Mechanism—Testing Susceptibility—Occurrence in Practice. G. T. COLEGATE, *Metal Ind.,* **73,** No. 25, 483-485; No. 26, 507-509; No. 27, 531-533 (1948).

The various forms of dezincification and the characteristics of the phenomenon are described. The tendency of an alloy to dezincify depends on the zinc content, the physical structure of the brass, the alloying constituents, and external influences. The principal alloying constituents discussed are: arsenic, antimony, phosphorus, bismuth, and tin, all of which tend, to a greater or lesser extent, to inhibit dezincification. The external influences considered are: oxygen supply, copper ion concentration, electrolytic stimulation, acid radicals, temperature, stress, and films deposited by waters. Accelerated laboratory testing of susceptibility with cupric chloride solution, and the method of dezincification in practice, are described. Twenty-eight references are appended.—MA.

Sulphate-Reducing Bacteria and Internal Corrosion of Ferrous Pipes Conveying Water. K. R. BUTLIN, MARY E. ADAMS AND MARGARET THOMAS. *Nature,* **163,** 26-27 (1949) Jan. 1.

Examination of "tubercles" on the inside of water mains shortly after removal from the soil disclosed presence of sulfide sulfur, elementary sulfur, severe graphitization of the cast iron underneath the "tubercles," and comparatively large numbers of sulfate-reducing bacteria. Conditions were roughly comparable to those obtained in anaerobic microbiological corrosion of ferrous-pipe exteriors. —BLR.

Corrosion and Incrustation of Well Screens. G. F. BRIGGS. *J., American Water Works Assoc.* **41,** 67-74 (1949) Jan.

Discusses above problems under the headings: definitions; forms of corrosion; conditions favorable to corrosion; anti-corrosion measures; forms and causes of incrustation; and overcoming incrustation.—BLR.

A Geographic Study of Deposits and Corrosion. F. N. ALQUIST, Dow Chemical Co. *Corrosion,* **5,** 45-53 (1949) Feb.

Research methods are outlined which enable operators to find the extent of corrosion and deposition in operating equipment due to the action of industrial waters. The composition of deposits is not a matter of geographical location because of water treatment and corrosion effects. This statement is based on data on deposits from 100 boilers, 23 condensers, and 34 pipeline deposits over an area of 10 states. Removal of deposits with inhibited hydrochloric acid and calculations from chemical analysis of drain acids allows estimation of the over-all average thickness of deposits and corrosion products. The operational corrosion of several boilers shows that over-all average thickness of iron oxide is 0.001 in. ±0.004 in. Eight illustrations, nine tables.—TDD.

Corrosion: Its Effect in Boiler Systems. R. L. Reed, W. H. and L. D. Betz. *Combustion,* **19,** No. 11, 28-33 (1948) May; No. 12, 43-49 (1948) June.

Discussion of theories of corrosion, action of oxygen in the boiler system, its removal by mechanical and chemical means, protection aganist its action in idle boilers, and corrosion by CO_2, NH_3, H_2S, acidity, and other physical factors. Corrosion can occur from chemical or physical factors or a combination. Proper solution to problem requires close study and correct evaluation of all chemical and physical conditions.—INCO.

The Effect of Cold Inflow Rate, Orifice Design and Storage Water Temperature on Stratification in Domestic Hot Water Storage Vessels. M. V. Griffith. Brit. Elec. and Allied Ind. Res. Assoc. *Tech. Rep.* Y/T12, 1947, 10 pp. 6s.

By means of an experimental installation incorporating a Perspex hot water storage cylinder, the effects of several variables on the degree of mixing of hot and cold water in the storage cylinder as hot water was drawn off were investigated. The chief variables were temperature, rate of inflow of cold water, and orifice design. Recommendations for the design of hot water systems are made.—BNF.

Corrosion-Fatigue of Steel Under Asymmetric Stress in Sea Water. A. J. Gould. *J. of the Iron and Steel Inst.,* **161,** 11-16 (1949) Jan.

Severity of corrosion-fatigue in sea water under reversed stress with superimposed tensile stress was found to be almost independent of mean stress, provided it is not excessive. The result was obtained on polished specimens, scale-covered specimens and specimens descaled by pickling.—BLR.

Hard Surfacing of Cast-Steel Propeller Blades. K. B. Young, H. J. Nichols, and M. J. Nolan. *Welding Journal,* **28,** 153-157 (1949) Feb.

Deals with examination of hard-surfaced cast-steel propeller blades after service in salt water in both warm and cold climates. Includes numerous illustrations.—BLR.

Some Corrosion Experiences in a Power Station. F. Scott and E. W. Gilham. Paper, Elec. Power Engineers Assoc., London (Dec., 1947); *Steam Eng.,* **17,** 447-51 (1948) Sept.

Severe corrosion has been found in the desuperheater tubes of a boiler unit. The corrosion products consisted of flakes of magnetic iron oxide and heavy deposits of spongy copper. Heavy deposits of calcium phosphate and disintegrated corrosion products have been found on the tube plates. A contributary factor to the accumulation of sludge in the desuperheater is the position of the blow-down connection, which is situated on the water connection from the mud drum at a point some distance from the desuperheater body. To eliminate this corrosion the pH of the feed water is maintained between 8.0 and 8.5 by limiting the ammonia content to about 0.06 ppm. The presence of a small reserve of sulphite in the boiler water reduces the risk of corrosion by oxygen.

Corrosion Experiences on Cold and Hot Water Pipes and Boilers. (In German.) W. M. Müller. *Archiv fur Metallkunde,* **1,** 480-487 (1947) Nov.-Dec.

A photographically illustrated general discussion, based in part on the examination of samples taken from water lines after various service periods, and in part on laboratory experimentation. Includes a section on the difficulties of welding of corroded metal. 11 ref.—BLR.

Galvanic Corrosion of Metals in Salt Water. *Metal Finishing,* **47,** 73 (1949) Jan.

Table shows relative activity of 29 different commercial alloys.—BLR.

PREVENTIVE MEASURES

• Cathodic Protection

The Use of Magnesium Anodes to Control Corrosion in Galvanized Water Heater Storage Tanks. Dow Chem., Mid., Mich. (1948). Num. Illus. 30 pp.

A full account of an investigation on the cathodic protection of hot dip galvanized hot water tanks by magnesium anodes. It was found that if the anode was correctly installed, it could completely stop or markedly reduce the corrosion of a tank which was working at 150° F. and having a draw-off rate of 35 gallons per day. A 1.05-inch rod will give protection for six years. The anode should extend to within 3 inches of the tank bottom and there should be a permanent low resistance electrical connection between the anode and the tank. Soft waters are more severe than hard waters on galvanized tanks, and the

magnesium anodes deposit a black protective film which is useful in preventing corrosive attack.—ZDA.

• Metallic Coatings

Aluminum-Clad Steel. *Light Metals*, **12**, No. 133, 62-63 (1949) Feb.

Aluminum-covered steel strip, known as "Feral" which was used considerably in pre-war Germany, is now coming into use again for the manufacture of flexible tubing, telephone diaphragms, electric cable protection, etc. The steel is of a quality suited to heavy pressing, its composition being 0.06% carbon, 0.04% sulfur, 0.04% phosphorous, 0.6% manganese and traces of silicon. Aluminum strips for coating the steel are 150 mm. wide by 6 mm. thick and contain from 0.6-1.0% silicon and 0.5% iron. They are cold rolled to a thickness of 0.20 mm., cut to the desired width, annealed in rolls, and then wound on reels with a special mounting on the plating mill, above and beneath the steel strip to be covered. The steel is supplied in hot-rolled sheet 150 mm. wide by 3.5 mm. thick. It is cleaned either with cold hydrochloric acid or hot sulphuric, washed in cold water and dipped in warm chalk-water. It is dried, cut, smoothed in a seven-roller press and passed to a brushing machine. Leaving this machine with a roughened surface, the strip passes to the aluminum cladding mill. A minimum reduction in thickness for the strip takes place during the cladding process. The temperature necessary to obtain good adhesion is produced and maintained by the actual rolling and pressing process, without any separate heating. On leaving the mill, the strip of aluminum-clad steel is wound on to a drum at extreme tension. The strip is finally annealed at a temperature varying between 535 and 550° C (995-1022° F) for 10 to 15 hours. Time and temperature are factors affecting the flexibility of the strip and the formation of $FeAl_3$ at the interface between the two metals. —ALL.

The Cladding of Metals. Josef Hoffmann. *Metallurgia*, **1948**, Nos. 17/18, 295-297; Nos. 19/20, 330-332.

A review of the nature and objects of cladding, the methods of producing and subsequently working clad material, its properties and applications, methods of testing, patented processes, and recovery of the clad coatings from scrap. There is a bibliography.—MA.

High Strength Hydrogen Peroxide for Rocket Propulsion. V. W. Slater and W. S. Wood. *J. Brit. Interplanet. Soc.*, **7**, 137-154 (1948); *British Abs.*, **BI**, 87 (1949) Jan.

Development, manufacture,and properties of 90% hydrogen peroxide discribed. Boilers and packed columns are of stoneware. Stainless, austenitic steels, tin, nickel, or heavily chromium-plated vessels can be used for storing and handling 90% hydrogen peroxide. Nickel, chromium, and manganese ions have appreciable destablizing effects.—INCO.

Weather-Tight Jacket. *Chem. Eng.*, **56**, No. 2, 154 (1949) Feb.

A new aluminum jacketing to provide outdoor protection for insulated pipes has been developed by Childers Mfg. Co., Houston, Texas. The material consists of a light sheet of corrugated aluminum backed up with a glued-on asphaltic moisture barrier. It is produced of 2-S alloy, 0.0055-in. thick, fabricated with 3/16-in. corrugations. The moisture barrier is a 70 lb. kraft paper impregnated with asphaltic compounds and coated on both faces with a sealing mixture of gilsonite, resins, waxes and special asphalts. The jacketing is supplied in rolls 4 ft. wide by 100 ft. long.—ALL.

Metal Spraying Wire Booklet. Issued by Chas. Clifford & Son Ltd., Dogpool Mills, Birmingham, 30. Jan., 1949, 2 Illus. 24 pp.

This little book describes the ferrous and non-ferrous wires which the firm supplies for all kinds of metal spraying work; 99.98 per cent pure zinc wire is available for zinc spraying steel structures needing protection against the corrosive action of the atmosphere, or against fresh water. (It is surprising that the value of sprayed zinc coatings in protecting sea-going vessels, etc., is not mentioned.) Tables show the weight per foot of the various metal and alloy wires, and of the average area covered by 1 lb. of wire when used to spray a coating 0.004 in. thick. Allowing for normal losses, 1 lb. of zinc wire covers 5 sq. ft.—ZDA.

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Protection of Iron by Thermally Produced Oxidized Covering Layers. ("Thermoxyd" Process). E. FENNER AND L. KOCH. *Archiv Metallkunde*, **2**, No. 2, 53-56 (1948) Feb. (In German).

After a preliminary dip in a special bath (no details) the iron is dried in air and heated for an hour at about 750° C. The surface is then treated with oil. Salt-spray, water spray and running water tests were carried out. The "Thermoxyd" coating is claimed to have superior corrosion-resistance and mechanical properties over phosphatised iron.—BNF.

Electroplate Finishes on Zinc-base Die Castings. E. E. HALLS. *Metal Treatment*, **15**, No. 56, 209-16 (1948-9) Winter.

A full description of the electrodeposits applied to zinc alloy die castings. General comments made on the choice of plating metals are: zinc would be superfluous; cadmium is unsuitable for damp conditions, but might be used to compensate for bimetallic junction; tin would only be chosen for easy soldering; copper is suitable for decoration or if high electrical conductivity is desired; nickel is the best, and if covered with a chromium flash gives an enduring finish of good appearance. Details of plating systems, coating thicknesses, corrosion tests, and plating solutions are given.—ZDA.

Hot Dip Galvanizing and Rust Prevention. Booklet published by the Hot Dip Galvanizers Association (a member of the Z.D.A.), Lincoln House, Turl Street, Oxford. Jan. 1949.

This booklet is divided into the following sections: the galvanizing process; rust prevention by galvanizing; the corrosion resistance of galvanized coatings; the characteristics of a good galvanized coating; and inspection and advances in technique. It contains descriptions of the process and the purpose of hot dipping, written in simple technical language for those interested in protective metal coatings, and is intended to show prospective users of hot dip galvanizing the advantages and limitations of the process. Illustrations support the text, and there are many views of the process in addition to numerous photographs showing the uses of hot dip coatings. The origin of the term "galvanizing" is discussed: it is believed to refer to the mechanism of protection against rust, rather than to the method of applying the zinc. Specialized galvanizing is not omitted, though this side of the industry is not considered in detail.—ZDA.

Metal Spraying by the Wire Pistol. Anon. *Ind. Fin.*, **1949.** 422-6, Feb.

A brief description of spraying using a pistol fed with metal wire. The adhesion and structure of the coating are explained and examples of the uses of the process are given. The paper by Hudson and Banfield (see ZDA Abs. No. 47/430) is quoted as containing a comparison of the three methods of metal spraying.—ZDA.

An Industrial Plant for Coating by the Evaporation Method. M. JOUANIGOT. *Vide*, **3**, No. 13, 381-386 (1948).

A plant for the coating of non-metallic surfaces with metals by the evaporation method is described.—MA.

"Mollerizing," A Method of Impregnating Steel and Iron Products with Aluminum. Linden & Co., Los Angeles, Cal. (1947) Mar.

The Mollerizing method of impregnating steel and iron products with aluminum offers an easy and economical means of protecting sheet, wire, pipe, castings, forgings, and fabricated parts against acids, fumes, and corrosive atmospheres. In addition, it improves the electrical and heat conductivity of the base metal. The method consists essentially of degreasing, descaling, and cleaning the metal part, and immersing it in an electric salt-bath furnace containing principally barium chloride at a temperature of 1600 - 2000° F on which is floated a top layer of pure aluminum. The thickness of the coating produced by the bath is dependent on temperature and dipping time.

Steel wire treated in the salt bath at 1508° F had an outer coating of aluminum of 0.0008 and 0.0016 in. at the end of 10 and 120 seconds respectively. For corresponding periods the inner aluminum-iron alloy layer was 0.0031 and 0.0059 in. thick.

Although Mollerized metals need no painting, they can be painted, oxidized, anodized, and polished in the same manner as aluminum. They can be heat treated, annealed, or shaped within wide limits. When quenched, the iron-aluminum bond layer may have a hardness equal to that of toolsteel, up to 550 Vickers Brinell, and will withstand severe abrasion and wear. Mollerized steel can be welded to steel or aluminum. Illustrations and tables.—PDA.

Coating by Metallization. J. CAUCHETIER. *Soudure et Techniques Connexes*, **2**, Nos. 9/10, 216-225 (1948).

A study of sprayed metals. The thickness of the sprayed coating can attain 15 mm. Consideration is given to the density, voids, micrographic structure of sprayed metals. The anti-frictional properties and adhesiveness of some sprayed metals are discussed.—MA.

Coating Iron with Lead in Molten Metal Baths. *Metalloberflache*, **2**, No. 7, 149 (1948).

The usual pickling processes are of little value in the hot dipping of iron in lead. The recommended procedure is to give a preliminary dip in a bath containing 5-10% tin and/or cadmium and then to finish in a bath containing pure lead, or to omit the preliminary dip and use a bath containing: 1) lead 8, tin 1, and antimony 0.1 part, or 2) lead with cadmium 1 and zinc 0.5%.—MA.

Conveyorized Galvanizing Process Installed at Rheem Plant. *Prod. Fin.*, **13**, No. 2, 104+ (1948).

Brief description of a completely mechanized hot-dip galvanizing plant used for zinc-coating steel hot-water tanks. The tanks are treated as two subassemblies which are welded together by resistance welding, which gives continuous re-fusion of the zinc coating.—MA.

Metal Spraying. J. PUSCHEL. *Werkstatt u. Betrieb*, **81**, 69-70 (1948); *Brit. Abs.*, **(B1)**, 725 (1948).

Developments since Schoop invented metal spraying in 1909 are reviewed, and the mechanism of the pistol is described. A special pistol is required for metals (such as steel) with a high m.p. The surface to be sprayed must be absolutely free from grease.—MA.

The Protection of Iron and Steel Structures by Metallic Zinc Paints. J. S. REMINGTON. *Chimie des Peintures et Vernis* (Switzerland), **1**, No. 7, 116-20 (1947) Oct. (In English).

Zinc dust/zinc oxide paints are particularly valuable nowadays, when there is much structural steelwork to be protected and few skilled painters available. This article provides detailed information about the manufacture of such paints, and 7 complete formulae are given, one of which is suitable for smoke-stacks, etc. It is recommended that, to avoid gassing in the can, the paints be made up with lime-treated zinc dust, i.e., a zinc dust which was mixed with quick-lime before screening. Two methods—one due to the author—are described for determining the metallic zinc content of zinc dust.—ZDA.

Electroless Plating on Metals by Chemical Reduction. *Tech. News Bull.* Nat. Bur. Stand., **31**, No. 10, 111-112 (1947).

A new process for plating nickel and cobalt on metal surfaces without the use of electric current has been developed in the bureau laboratories. The reaction, which is catalytic, is brought about by chemical reduction of a nickel or cobalt salt with hypophosphite in hot solution. Careful control of concentration and pH are necessary, and no plating occurs until certain metals, such as steel or nickel, are introduced into the bath. The adherence of the coating is very good, and its purity 93-97%. The deposit is sound, but brittle, although it may be rendered ductile by subsequent annealing at 400°-600° C. It is claimed that the process is particularly useful for irregular, recessed, and tubular objects, which require complicated electrode arrangements in electroplating. The process is described in some detail, and a table of suggested compositions of suitable solutions is given, with photomicrographs of the coatings before and after heat-treatment.—MA.

Sprayed Metal Coatings—Their Structure, Properties, and Uses. JOHN E. WAKEFIELD. *Metal Prog.*, **54**, No. 6, 827-832 (1948).

W. presents some new data on the porosity, coeff. of friction, tensile strength, and hardness of sprayed coatings of a number of metals and alloys produced by the wire-gun method. Sprayed coatings are more porous than the corresponding materials in compact form and have lower coeff. of friction; in certain cases (e.g., the aluminum alloy containing 6% silicon) a sprayed coating is stronger than any other form of the material. The advantages and limitations of sprayed coatings in engineering practice are reviewed, and applications of metal spraying are briefly dealt with under the headings electrical, mechanical, and protective. Also includes some notes on corrosion resistance.

Surface Treatment and Finishing of Light Metals—Pt. 2. Corrosion and Protection of Aluminum and Its Alloys. S. WERNICK & R. PINNER. *Sheet Metal Inds.* **26**, No. 264, 805-810+ (1949) Apr.

Discussion includes protective characteristics of aluminum, corrosion af aluminum, super-purity aluminum, and cladding of aluminum. Main factors affecting corrosion in aluminum and its alloys include chemical action, dissimilar metal contact, mechanical action, and

intergranular and stress corrosion. Duraplat, a copper-free Dural cladding on Duralmin, gave excellent corrosion test results as long as it was not frequently or lengthily annealed. A type of coating allied to cladding is Cupal, an electrodeposit of copper used on aluminum sheet, tubing and wire, and normally from 10-30% of thickness of alloy. 12 references.—INCO.

• Non-Metallic Coatings

New Exterior Paints for H.M. Ships. *Admiralty Bull.* No. 16, Jan. 1949. 4 pp.

The battleship grey paint used by the Royal Navy until the recent war had the following formula: white lead oil paste 50 lb.; zinc oxide white oil paste 28 lb.; liquid driers 3 pints; raw linseed oil 21 pints; blue black paste 7 pints; and 6 pints of light grey enamel to each cwt. of paint. This formulation has been superseded by one based on titanium dioxide and antimony oxide, which is not given in detail. The new paint is claimed to have improved chalking characteristics and is more durable. It is applied over a zinc chromate iron oxide primer which has and oil-modified alkyd resin medium. The primer is an improvement over the red-lead-in-oil primer, but is not considered to be completely satisfactory for steel.—ZDA.

A Study of Primers for Ferrous Metals in an Atmospheric Exposure Progress Report IV. Anon. *Amer. Paint J. Convention Daily*, **33**, (6-B), 8-10+ (1948) Nov. 6; **33** (7-A), 28-32 (1948) Nov. 9.

An interim report on the condition of steel panels painted with recommended paint systems, after about one year's exposure. Only slight deterioration had occurred, so little is to be learned from the results at present. However, a few panels were given priming coats only, and from them it appears that red lead and zinc chromate are better than basic carbonate white lead, iron oxide or aluminum. Zinc chromate, zinc oxide and leaded zinc oxide are components of many of the hundreds of paints under test, for which the experimental data are summarized in a table.—ZDA.

American Gum Importers Labs. Prime Coatings. *Can. Paint & Var. Mag.*, **22**, No. 9, 16, 48-56 (1948).

Primers based on tung, fish, linseed, oiticica, dehydrated castor and soybean oils and combinations with natural and phenolic resins and pigmented with zinc chrome, red led and zinc dust, were applied to steel panels and evaluated under exterior exposure and by immersion in salt water. The best oils were bodied linseed, linseed/oiticica and linseed/tung mixtures and the best resins. Black East India and Congo resins. 25-gall. oil-length varnishes gave generally good results. Red lead and zinc chrome were the best pigments.—RPI.

Relationship Between Fungistatic Activity and Structure in a Series of Simple Aromatic Compounds. G. W. K. Cavill, J. N. Phillips and J. M. Vincent. *J. Soc. Chem. Ind.*, **68**, No. 1, 12-6 (1949).—RPI.

Primer for Metal. *Chem. Eng.*, **56**, No. 2, 174 (1949) Feb.

Rust-O-Primer, developed by the Wilbur and Williams Co. of Boston, is a vinyl-base, quick-drying, wet primer, applicable over wet or dry, clean or rusted metal, including steel, aluminum or galvanizing. It provides a hard, paintable foundation for any type of paint, including ship-bottom paints, as well as acid-caustic bond vinyl-type of finish.

The Fight Against Corrosion. Association Belge Pour L'Etude, L'Essai et L'Emploi Des Materiaux. *Chim. Peint.*, **12**, No. 1, 33-4 (1949).

An outline of the research programs initiated by the ABEM for evaluating paints as corrosion-preventing systems. —RPI.

Organic Coatings for Industrial Structures and Equipment. R. Devoluy. *Can. Paint & Var. Mag.*, **22**, No. 8, 30-33, 39 (1948).

A description of the use of vinyl resins as bases for the preparation of priming, anti-corrosive and top-coat paints for steelwork. The system was based on results obtained from ships' bottom paints and considerations of the electrolytic resistance of organic coatings. High abrasion resistance, chemical resistance and rapid drying are claimed.—RPI.

Ship Painting. G. Diehlman and R. P. Bates. *Mar. Eng. Ship. R.*, **53**, 66, (1948) Nov.; *J. Brit. Shipbuilding R. A.*, **4**, No. 2, 92 (1949).

The authors re-state the basic principles governing the painting of ships as a protection against corrosion and fouling. The main interest of the article lies in the formulae given for paint systems

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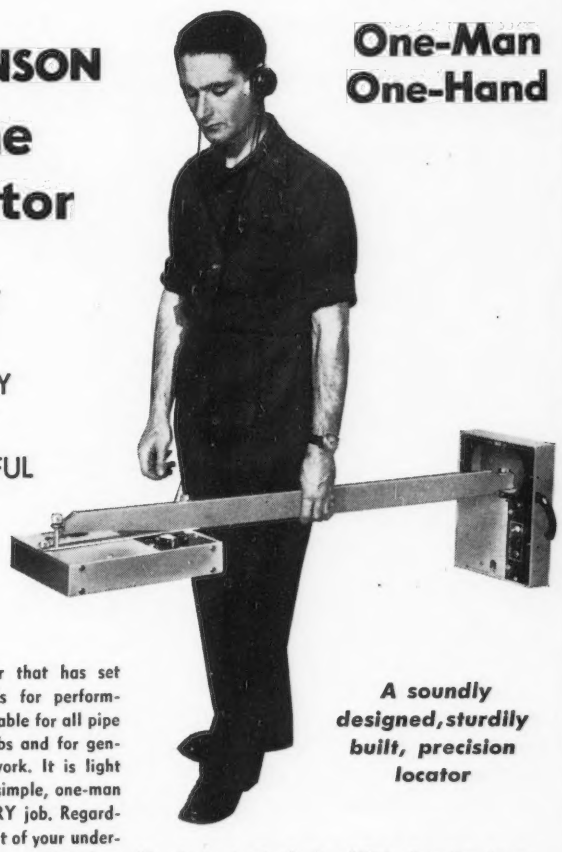

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Synthetic Resins and Rubber Derivitives as Anti-corrosives. I. F. G. ESTARTUS. *Afinidad*, **25**, 355-9 (1948); *Brit. Abs.* B-II, 557 (1948).

Marine corrosion and its prevention, mainly by means of synthetic resins, are dealt with. The nature and mechanism of corrosion are briefly discussed, and the requirements of a good protective film indicated, together with the main characteristics of an efficient anti-fouling composition. Marine anti-corrosive coatings may be based on phenolic resins soluble in drying oil or on chlorinated rubber, which is now generally preferred.

Fireproofing Agents. I. G. FARBENINDUSTRIE. PB. 63710, Frames 34-7; *Prev. Det. Abs.*, **5**, (1948), Plas 32.

A composition is prepared on the basis of an aq. solution of a urea/formaldehyde resin, sugar, $(NH_2)_4HPO_4$ and borax. —RPI.

Paint. *The Foundry*, **77**, No. 3, 177 (1949) Mar.

A new paint, available in aluminum and black, may be applied directly over rusty surfaces without cleaning or scraping. It is reputed to penetrate the rust layer, render it inactive and seal the surface against further rusting. It may be painted over with any paint or enamel. Also available is a high heat-resisting aluminum paint designed for use in painting boilers, furnaces, condensers, compressors, ovens, stacks, engines, steam lines, exhaust manifolds and other interior or exterior metal surfaces. It also may be used for painting wood, brick or concrete surfaces. Both paints are products of Speco, Inc., Cleveland, Ohio.—ALL.

Corrosion Protection of Zinc Parts with Paints. *Galvano*, **129**, 19 (1947).

Four paints are described.—MA.

The Production of Colors and Protective Films and Zinc Alloys. *Metalloberflache*, **2**, No. 7, 146-149 (1948).

Most of the non-electrolytic processes for the coloring and surface protection of zinc and its alloys are briefly described.—MA.

Paints for the Protection of Zinc Objects. Anon. *Galvano*, **16**, No. 129, 19 (1947); *Electroplating*, **1**, No. 4, 148 (1948).

A number of formulae are given.

The Choice of Paint. J. A. GASCOIGNE. *Ind. Fin.*, 484-8 (1949) Mar.

A general survey of paint constituents, classified as varnishes, pigments and solvents. The section on white pigments contains no mention of zinc oxide, but reference is made to lithopone, which has good properties but is said to be inferior to titanium dioxide in reducing power and resistance to acids. Zinc naphthenate is classed as a "drier."—ZDA.

Organic Finishing of Magnesium. ALLEN G. GRAY. *Prod. Fin.*, **13**, No. 4, 72+ (1949).

Emphasizes the importance of the correct choice of priming coat. Zinc chromate pigment is recommended, provided it has low sulphate and low chloride content. Red oxide has also proved satisfactory, but pigments such as graphite which may give rise to galvanic action should be avoided. Resistance to moisture permeability is also important in primers for magnesium. Two coats should be used. Choice of finishing coat depends almost entirely on conditions of exposure anticipated.—MA.

Strippable Plastic Coating Protects Surface Finishes (on steel). A. G. GRAY. *Prod. Fin.*, **12**, No. 1, 54-8 (1948); *J. Iron & Steel Inst.*, **159**, 226 (1948).

The use of easily removable plastic coatings to prevent damage to stainless steel during pressing and drawing is discussed.—RPI.

Paint in Civil Engineering—A Review. R. HAMMOND. *Paint Manuf.*, **18**, No. 10, 343-6 (1948).

The causes of rust-formation, the importance of descaling iron and steel surfaces and the filling of crevices left by welded joints are mentioned. Where descaling is impossible, a thin coat of red lead paint may be applied to keep the scale intact during fabrication. While paints do not adhere well to galvanized iron, they take very well on zinc coating applied by spraying (e.g., by the Schori method). Tar/aluminum paint has proved a satisfactory paint for steelwork protection.—RPI.

Heat Resistant Paint. *Internat. Chem. Eng. & Process Inds.*, **30**, No. 3, 134 (1949) Mar.

A paint which will resist temperature up to 1000° F has as its basic constituent butyl titanate, which is produced from rutile and ilmenite of "black sand" beach deposits. Tests carried out inside main flue stack of a boiler plant showed that new paint remained intact after 32 weeks, while ordinary paint had completely disappeared and corrosion of steel base had commenced. Paint is also reported to afford protection against salt water and preliminary tests show that submerged parts of ships require less repainting with new paint than with conventional products. The titanate is not inflammable. Announced by Council for Industrial and Scientific Research.—INCO.

The Protection of Steel Against Atmospheric Corrosion and Marine Fouling. Discussion. *J. Iron & Steel Inst.*, **161**, No. 2, 91-102 (1949) Feb.

A discussion of papers presented to the Iron and Steel Institute in 1948, including the following noted in these abstracts: 48-172, The Protection of Iron and Steel by Various Non-metallic Coatings (J. C. Hudson and T. A. Banfield); 48/824, Studies in Anti-fouling Compositions (H. Barnes); 48/241, Cementiferous Paints (J. E. O. Mayne and R. S. Thornhill); and 48/242, Marine Exposures of Cementiferous Painting Schemes (K. A. Pyefinch.)—ZDA.

Finishes for Light-metal Transportation Equipment. L. C. MANN. *Org. Fin.*, **7**, No. 2, 459 (1948); *Chem. Abs.*, **43**, No. 1, 420d (1949).

Recommended techniques are given for coating railway and bus equipment. The necessity is stressed for chemical treatment of aluminum and magnesium before coating to ensure adequate protection.—RPI.

Chlorinated Rubber in Protective Coatings Field. J. B. MARTIN, Hercules Powder Corp. *Can. Chem. Proc. Inds.*, **33**, No. 3, 208-210 (1949) Mar.

Chlorinated rubber is used as a base for maintenance paints and concrete finishes. In alkyd and varnish finishes it speeds drying, increases hardness and improves resistance of coating. Photographs illustrate the point of the article. —INCO.

A Paint Finish for Domestic Goods. O. MARTIN. *Ind. Fin.* (U.K.) 417-21 (1949) Feb.

Washing machines, wringers, etc., are finished in the works described. An interesting though minor application of sprayed zinc is on the tub of a washing machine. The inside of the top rim is sprayed before phosphating and enameling. The treatment prevents the enamel wearing away at these points.—ZDA.

Protection of Metal Ships' Bottoms. H. MASSEILLE. *Chim. Peint.*, **11**, No. 7, 218-21 (1948); No. 1, 36-40 (1949).

A historical review is followed by a brief mention of recent ideas on and methods of combating corrosion.—RPI.

Tropic Proofing. Ministry of Supply and D.S.I.R. H.M.S.O. 1949. 32 pp.

In this general survey, little mention is made of the behavior of zinc goods in tropical conditions. It is interesting to note, however, that Sherardized fittings are recommended for leather goods, in place of the usual iron; and a zinc chromate pigmented lanoline resin is suggested for the protection of light alloys. The section on paints indicates that the ultraviolet absorption and antiseptic properties of zinc oxide should be beneficial, but that chalking tendencies would be much aggravated. Dark colored finishing paints are said to be more durable than light-colored ones in direct outdoor exposure.—ZDA.

Formulation of Corrosion Resistant Paint. J. W. NEE. *Corrosion*, **4**, No. 12, 599-610 (1948) Dec.

The use of zinc chromate in anti-corrosion paints is described. The chromate and oxide both improve the performance of paints pigmented with iron oxide. Basic zinc chromate in a vinyl vehicle was outstanding for steel panels immersed in sea water. There is a long section on vehicles for corrosion resistant paints.—ZDA.

Painting of the Eiffel Tower. C. A. ORSERO. *Ind. della Vernice*, **2**, No. 11, 275-7 (1948).

Protection against rust is provided by a paint based on a special naturally occurring micaceous iron oxide in a medium of linseed and tung oils, which is applied once every 7 years.—RPI.

Large Steel Products Company Protects Galvanized Steel with Zinc Dust Paints. Anon. *Paint Prog.*, **7**, No. 3, 1-3 (1948) Sept.

Notes on zinc dust paints classified according to their vehicles, and a description of the painting of galvanized structures. A linseed oil paint was used on phosphated galvanized steel so that when it became necessary to replinish the zinc coating, this could be done by repainting. The illustrations show typical applications of this coating system.—ZDA.

Fume-proof Paints Invade General House Paint Field. Anon. *Paint Prog.*, **7,** No. 3, 6-7 (1948) Sept.

These paints do not contain pigments which form dark-colored sulphides, and, therefore, they do not darken in industrial atmospheres containing sulphur compounds. The pigment mixture contains a balanced blend of titanium dioxide, zinc oxide and selected extenders. The properties of the paints are described, and photographs of buildings, after 6 years' weathering, show that these paints are durable and attractive.—ZDA.

Phosphate and Colored Plastic Coatings (for Metals). G. H. PIMBLEY. *Org. Fin.*, **8,** No. 11, 9+ (1947); *J. Iron & Steel Inst.*, **159,** 226 (1948).

The use of the coatings for protection and decoration is discussed.—RPI.

Corrosion-Protective Films. F. RITTER. Berg.—u. huttenmann. Monatsh. montan. *Hochschule Leoben*, **93,** 42-4 (1948); *Chem. Abs.*, **42,** No. 21, 8492i (1948).

A general discussioon of naturally formed (oxide) films and of paints and lacquers. Natural films created by chemical reaction between metal and attacking substances have the valuable property of regenerating themselves when damaged.—RPI.

Paints for Marine Use. Anon. *Shipping World* (1949) Jan. 12.

A brief survey of recent literature on paints for marine use. Modern anti-corrosive and anti-fouling paints are described, including zinc dust and cementiferous paints. Among the less familar formulations mentioned are oil modified phenolics and alkyds pigmented with zinc oxide for protection against corrosion. No details are given on the actual performance of the paints but there are references to the original papers.—ZDA.

Paints and Protective Coatings. W. A. SPERRY. *Sewage Works J.*, **20,** 319-23 (1948); *Chem. Abs.*, **42,** No. 22, 919b (1948).—RPI.

On the Chemical Production of Thick Protective Coatings of Magnesium Fluoride on Magnesium Alloys. M. STAESCHE. *Arch. Metallkunde*, **2,** No. 3, 99-102 (1948).

A study was made of the formation of protective coatings of magnesium fluoride on mangesium alloys containing aluminum (3, 6, or 8%), manganese or manganese and cerium. The optimum conditions were found to be: 1) treatment in aqueous solutions of sodium hydroxide (50-100 g./1.) at $<170°$ and $>180°$ C under a pressure of 5 atm., the temp. being reached over a period of ~1 hr. and then being maintained for 15 min.; fine-grained, polished, firmly adhering films of Mg $(OH)_2$ were produced, which varied in thickness from 10-100μ according to the temp. and type of alloy; 2) subsequent heating for 30 min. in hot, acueous solutions of neutral or acid fluorides or silico-fluorides (strength not given). Extraordinary resistance to aqueous and chemical corrosion was shown by films only 20μ thick; when immersed in sea water containing 0.1% hydrogen peroxide for 30 days the specimens were completely unattacked and were greatly superior to specimens treated by the dichromate process. Specimens were also very resistant to ignition at temp. beyond the m.p. of the alloy.—MA.

Solder Stops Steel Tube-Sheet Corrosion. E. R. STAUFFACHER, Southern California Edison Co., Los Angeles, Calif. *Corrosion*, **4,** No. 6, 19 (1948) June.

To combat the electrolytic corrosive action which resulted from the use of aluminum-brass condenser tubes and mild steel tube sheets in circulating brine, several types of protective coatings were applied to tube sheets. The efficiency of lead, tin, zinc, monel, 50% lead-50% tin solder, and several types of organic coatings was evaluated.

A 50% lead—50% tin solder covered with several layers of organic coating gives good results and may be efficient for at least 2-3 yr. Cathodic protection offered by circular zinc plates is also effective as a supplementary protection in minimizinng galvanic action.—PDA.

Corrosion Investigations of the Ingeniorsvetenskapsakademi. G. TENGSTRAND. *Farg och Fernissa*, **12,** No. 6, 81-5; No. 7, 103-7; No. 9, 136-9; No. 10, 155-8; No. 11, 171-3; No. 12, 177-80 (1948).

The results of exposure tests covering 21 primers and 50 finishing coats (formulations given in detail), several exposure stations, and extending over 9 yrs. are reported in general terms. Finishing coats were usually compared over a red lead primer and primers under a finish pigtd. with micaceous iron oxide, and aluminum. An exception was made with alkyd paints which were examined as a complete system. Three-coat systems gave much better results than two-coat systems, but the performance of individual paints was much more dependent upon the locality and on the exposure conditions (front or back panel, horizontal, or inclined position). Normal types of anti-corrosive primer containing a true anti-corrosive pigt. in sufficient quantity generally performed the best. Some unorthodox types of primer were unsuccessful. For between coats, good results were given by micaceous iron oxide/aluminum paints. For finishing coats, white lead or white lead/aluminum paints gave a high performance provided that they were used in conjunction with a polymerized oil; if a simple boiled linseed oil was used as medium, the results were much poorer. Other white pigts. had poor durability. Micaceous iron oxide/aluminum paints were also good as finishing coats.—RPI.

Protective and Decorative Coatings. L. M. TOWNE. *Ind. Gas*, **27,** No. 1, 5-7, 22-3 (1948); *Chem. Abs.*, **42,** No. 20, 7697g (1948).

A brief description of Bonderizing and other metal-finishing treatments.—RPI.

Recent Progress in Metal Priming Paints. J. F. H. VAN EIJNSBERGEN. *Chim. Peint.* **10,** No. 9, 265-70; No. 10, 304-5 (1947).

The properties of media, pigments and paints which have specific application to the requirements of corrosion protection are considered and the importance of the newer materials is noted.—RPI.

Rubber Coating for Steel. W. H. J. VERNON. Rubber Developments, 1948, Dec.; *India Rubber J.*, **116,** No. 4, 11 (1949).

A flexible latex rubber coat in which 5% sodium benzoate (based on the rubber) is incorporated keeps metal bright and free from rust even under humid conditions. Sodium benzoate will also act as a rust inhibitor in other aqueous film-forming dispersions.—RPI.

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Application and Performance of Bottom Paints. A. WARD. *Pac. Mar. Rev.*, **45,** 67 (1948); *J. Brit. Shipbuilding R.A.*, **3,** No. 11, 518 (1948).

The relative merits of plastic and conventional ship bottom paints are discussed, the preference being for the latter. The importance of thorough cleaning is empahsized and power-driven roller-shaped wire brushes are recommended. For application, a wide field of use is foreseen for pressure-fed brushes. —RPI.

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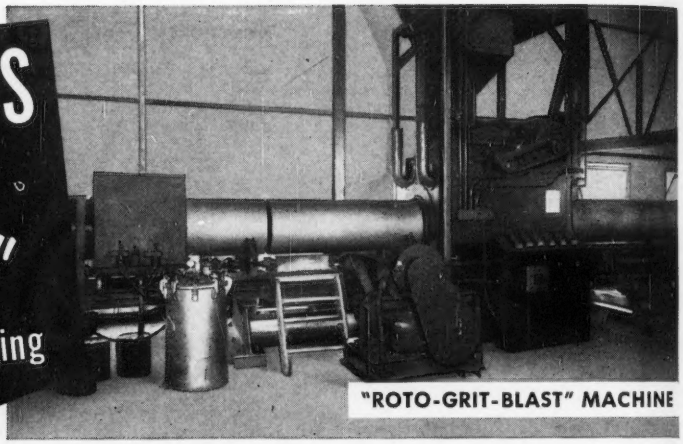

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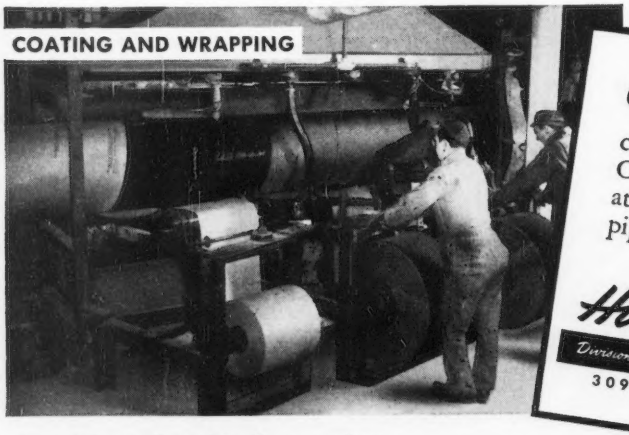

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Curll, Vincent A., Philadelphia, Pa.
Curran, James J., Greensburg, Pa.
Curran, Michael .....Tulsa, Okla.
Cushing, Daniel.....Boston, Mass.
Cushman, George A., Brenham, Tex.
Cutting, Merritt E.....
.....South Barre, Mass.

D

Dale, Dudley R.....Toledo, Ohio
Dalton, G. M.....
.....Hamilton, Ontario, Canada
Daniels, Leonard J., Jr.....
.....Fort Worth, Tex.
Dantz, Thomas M., New York, N. Y.
Darling, P. E.....Texas City, Tex.
Darrin, Marc.....Baltimore, Md.
Daugherty, M. W....Lakewood, Ohio
Davidson, James L., Jr.....
.....Garden City, N. Y.
Davie, Frank E.....Tracy, Calif.
Davis, Billy Harlan.....
.....College Station, Tex.
Davis, Carl R.....Butte, Mont.
Davis, Edwin G., Haddonfield, N. J.
Davis, F. W.....Cambridge, Mass.
Davis, George W.....
.....San Francisco, Calif.
Davis, J. E.....Fort Worth, Tex.
Davis, Jas. A.....Fort Worth, Tex.
Davis, Leon B...Washington, D. C.
Davis, Leroy J.....Glencoe, Ill.
Davis, L. W.....Cleveland, Ohio
Davis, Robert A., Birmingham, Ala.
Davis, Russell L.....
.....Awali, Bahrein Island
Persian Gulf
Dawson, R. A. J.....Houston, Tex.
Day, Stephen D.....Houston, Tex.
Deacon, Wm. T.....St. Louis, Mo.
Deacon, William T., III.....
.....St. Louis, Mo.
Dean, Roy O.....Emeryville, Calif.
Deavenport, John L...Gorman, Tex.
Debeers, Franklin M., Jr.....
.....Chicago, Ill.
Debord, George E.....
.....Galena Park, Tex.
Deering, F. A.....Arkansas, Kan.
Degenhart, Thurlo E.....
.....Vallejo, Calif.
Degnan, Thomas F.....
.....Penns Grove, N. J.
Dehaan, Peter C...Des Moines, Iowa
Delahay, Paul....Baton Rouge, La.
De Long, William B.....
.....Wilmington, Del.
De Mey, C. F.....New York, N. Y.
Deichler, J. K.....Philadelphia, Pa.
Denison, Irving A.....
.....Washington, D. C.
Denoon, E. M.....Miami, Fla.
Dent, Herbert W., Jr.....
.....Birmingham, Ala.
Deringer, Wayne A.....
.....Milwaukee, Wis.
De Rouen, H. A.....Houston, Tex.
Derrick, H. R., Chattanooga, Tenn.
Detrick, Charles N., Cleveland, Ohio
Deuber, Carl G.....
.....Briarcliff Manor, N. Y.
Devoluy, Raymond, New York, N. Y.
Dewar, J. S.....Bartlesville, Okla.
Dewar, William....Philadelphia, Pa.
Deweese, R. W.....Portland, Ore.
Dewey, Wm. S.....New York, N. Y.
Diamond, Horace W....Chicago, Ill.
Dickinson, L. R...New York, N. Y.
Dickinson, W. F., Los Angeles, Calif.
Dickson, Lester R.....Harvey, Ill.
Diecks, A. N.....Milwaukee, Wis.
Diehlman, George...Brooklyn, N. Y.
Dietsch, F. F...Washington, D. C.
Dietze, Irwin Charles.....
.....Los Angeles, Calif.
Diggins, Earl R.....
.....New Kensington, Pa.
Dillon, Charles P., Texas City, Tex.
Dishman, L. F....Montebello, Calif.
Dix, E. H., Jr.....
.....New Kensington, Pa.
Dod, A. Bayard, Jr.....
.....Los Angeles, Calif.
Dolson, Frank E., Jr.....
.....University City, Mo.
Donati, Enrico .....
.....Dalmine, Bergamo, Italy
Donnelly, Joseph B.....
.....Philadelphia, Pa.
Donoho, Chas. K., Birmingham, Ala.
Donovan, Lewis B., New York, N. Y.
Donovan, W. H., Jr.....
.....Birmingham, Ala.
Doremus, E. P.....Houston, Tex.
Doremus, Gordon L...Houston, Tex.
Dorsey, Joseph S.....
.....Los Angeles, Calif.
Doss, Glenn K.....Elizabeth, N. J.
Dotterweich, Frank H.....
.....Kingsville, Tex.
Dougherty, Wm. J., Sioux City, Iowa
Doughty, S. E.....Union, N. J.
Douglass, E. W.....Carlsbad, N. M.
Douglass, Harry E.....
.....Los Angeles, Calif.
Dowling, Roy C.....Appleton, Wis.
Dragics, Earl V.....Houston, Tex
Draughon, Charles R.....
.....Baton Rouge, La.
Dubois, Carlton H....Buffalo, N. Y.
Duggan, James J.....
.....South Charleston, W. Va.
Duim, Albert R...Hawthorne, Calif.
Dunasky, C. F.....Cleveland, Ohio
Dunham, R. A...Long Beach, Calif.
Dunlap, Gordon E....Mahwah, N. J.
Dunning, Sheldon....Seattle, Wash.
Durning, A. W...New Orleans, La.
Dutton, W. L.....
.....Chatham, Ontario, Canada
Dwyer, James T., Jr.....
.....Port Arthur, Tex.
Dwyer, T. J.....Baltimore, Md.
Dyble, Edward.....Cleveland, Ohio

E

Earle, Ralph H.....
.....South Milwaukee, Wis.
Easson, W. H.....Chicago, Ill.
East, Leo H.....Rochester, N. Y.
Eberhardt, Ernest T.....
.....Hackensack, N. J.
Ebersole, Larue Kenmore.....
.....Colorado Springs, Colo.
Eckles, W. W.....Beaumont, Tex.
Eddison, Clifford.....Camden, N. J.
Eddy, Levi C.....Hinsdale, Ill.
Edmonson, A. Glen.....
.....Jacksonville, Fla.
Edwards, Marvin J.....
.....San Diego, Calif.
Edwards, W. H.....Bellaire, Tex.
Effinger, R. T.....Martinez, Calif.
Egly, Richard S., Terre Haute, Ind.
Eickhoff, Arnold J., Brooklyn, N. Y.
Ellerts, C. Kenneth.....
.....Bartlesville, Okla.
Elder, John W.....Tulsa, Okla.
Eldred, Norman O.....
.....Vicksburg, Mich.
Eldredge, George .....
.....Emeryville, Calif.
Elkins, Randell L.....
.....Great Bend, Kan.
Elliott, Jack H., Los Angeles, Calif.
Elliott, Robert D.....Dallas, Tex.
Ellis, O. B.....Middletown, Ohio
Elliston, H. H.....Tulsa, Okla.
Elsener, L. A., San Francisco, Calif.
Emerson, Richard J...El Paso, Tex.
Endicott, L. A.....Texas City, Tex.
Engelhardt, Robert Lee.....
.....Glendale, Calif.
Engemoen, R. J.....Houston, Tex.
Engle, J .Preston.....Alliance, Ohio
English, E. Rowland.....
.....Philadelphia, Pa.
English, Gyme C.....
.....New Kensington, Pa.
English, James L.....
.....Oak Ridge, Tenn.
Enquist, Melvin A.....
.....Alhambra, Calif.
Eplett, Albert D., Stratford, Conn.
Erganian, Alex M....Houston, Tex.
Erickson, Bert E.....
.....Salt Lake City, Utah
Erickson, C. A., Jr., Pittsburgh, Pa.
Erickson, E. T.....Chicago, Ill.
Ericson, Rudolph C., Hammond, Ind.
Eubanks, E. B., Jr.....
.....Riverdale, Calif.
Evans, Charles T., Jr., Delmont, Pa.
Evans, Clair O., Los Angeles, Calif.
Evans, C. W.....Shreveport, La.
Evans, Dwight J.....Houston, Tex.
Evans, Herbert V., Jr.....
.....Pittsburgh, Pa.
Evans, J. M...San Francisco, Calif.
Evans, Rulison...Wilkes-Barre, Pa.
Evans, Thomas C.....Orange, Tex.
Everest, Guy N.....
.....Canal, Passaic, N. J.
Everett, Albert S.....
.....San Francisco, Calif.
Everett, Ralph H., New York, N. Y.
Everhart, E. Wayne.....
.....Spokane, Wash.
Ewing, L. W., Jr.....Chicago, Ill.
Ewing, Scott P.....Tulsa, Okla.

F

Fair, W. F., Jr.....Pittsburgh, Pa.
Fanett, H. M.....Houston, Tex.
Farber, J. D.....Philadelphia, Pa.
Farkas, Howard...New York, N. Y.
Farmer, C. E.....Shreveport, La.
Farrar, Walter B.....Bethesda, Md.
Farwell, Milo S.....
.....San Francisco, Calif.
Fasold, G. Arthur, Cincinnati, Ohio
Featherly, Robert L.....
.....Saginaw, Mich.
Febrey, H. H.....Cleveland, Ohio
Feldman, Karl T.....Marion, Ohio
Fell, Paul D...Independence, Kan.
Feller, Eugene W. F.....
.....New York, N. Y.
Fellows, C. H.....
.....Huntington Woods, Mich.
Fenner, Otto H.....St. Louis, Mo.
Fergus, D. J.....Cleveland, Ohio
Fergusson, Robert A., Evanston, Ill.
Fernandez, Henry J.....
.....Texas City, Tex.
Fernandez Y, Grajales, Bernardo...
.....Mexico City, Mexico
Ferree, Ray J.,.....St. Louis, Mo.
Fetner, J. C., Jr., Pittsburgh, Pa.
Fetter, Edmond C.....
.....New York, N. Y.
Fetters, Karl L...Youngstown, Ohio
Fink, Frederick W., Columbus, Ohio
Fischer, H. E.....Houston, Tex.
Fisher, B. M.....Freeport, Tex.
Fisher, George A., Jr.....
.....St. Louis, Mo.
Fisher, H. E.....Chicago, Ill.
Flanagan, J. C.....Houston, Tex.
Fleming, M. C...Bartlesville, Okla.
Fleming, Thomas J.....
.....Santa Monica, Calif.
Flentje, Martin E., New York, N. Y.
Fletcher, Frederic H...Tulsa, Okla.
Fletcher, Mark D.....Chicago, Ill.
Flickinger, L. C., Youngstown, Ohio
Flint, J. W.....Wichita, Kan.
Flocke, Frank G....Cleveland, Ohio
Flood, Earl F.....Hudson, Ohio
Flor, Loy L.....La Mesa, Calif.
Flournoy, R. W.....Argo, Ill.
Flynn, E. D.....Oakland, Calif.
Foelsch, Henry W.....Chicago, Ill.
Foley, Francis B...Philadelphia, Pa.
Folse, J. B.....Houston, Tex.
Fontana, Mars G...Columbus, Ohio
Footner, H. B.....
.....Great St. Helen's, London
E. C. 3, England
Forbes, A. L., Jr.....Houston, Tex.
Forbes, M. C.....Kingsville, Tex.
Forsman, Robert A.....Tulsa, Okla.
Fossett, W. K.....Wichita, Kan.
Foster, Albert C., New York, N. Y.
Foster, J. L.....Dallas, Tex.
Fox, Arthur R.....Oakland, Calif.
Fox, R. W.....Drexel Hill, Pa.
Francis, Howard T.....Chicago, Ill.
Franek, John A....Cincinnati, Ohio
Frank, Marion E.....Houston, Tex.
Frasch, H. H.....Dallas, Tex.
Fraser, William R....Detroit, Mich.
Frederickson, Hubert M.....
.....Minneapolis, Minn.
Freeman, Cecil .....
.....San Francisco, Calif.
Freeman, John R., Jr.....
.....Waterbury, Conn.
Freeman, Richard S.....
.....Lake Charles, La.
Freynik, Henry S...Riverside, N. J.
Friant, Stewart.....Baltimore, Md.
Friedman, Charles .....
.....Long Island City, N. Y.
Friedrichs, C. C.....Houston, Tex.
Friend, W. Z.....New York, N. Y.
Frink, Joe.....Miami, Fla.
Fritts, Harry W.....
.....New Kensington, Pa.
Friz, Nelson.....New York, N. Y.
Fry, Frank B.....Denver, Colo.
Frye, Seymour Charles.....
.....Bethlehem, Pa.
Fryer, Carl V.....Cyril, Okla.
Fugazzi, John F.....Denver, Colo.
Funk, F. W.....Akron, Ohio
Furgason, Clyde A.....Cudahy, Wis.
Furth, M. A.....Nederland, Tex.
Fyke, F. C.....Elizabeth, N. J.

G

Gaido, S. J.....Harvey, La.
Gaidry, H. L.....New Orleans, La.
Gallagher, John S.....
.....Los Angeles, Calif.
Galloway, Joseph F.....
.....Cleveland, Ohio
Gally, Sidney K....Pasadena, Calif.
Gamble, Chas. B., Birmingham, Ala.
Garber, Glenn D., Lake Charles, La.
Garcia, Luis.....Wayne, Mich.
Gard, Charles M.....
.....Worthington, Ohio
Gardner, Franklin T., Tulsa, Okla.
Gardner, G. Douglas, Louisiana, Mo.

Gardner, Gerald C.....Hazelwood, Pittsburgh, Pa.
Garrett, Fred A.....Dallas, Tex.
Garrett, G. H.....Denver, Colo.
Garrett, William W.....Birmingham, Ala.
Garrison, V. L.....Paterson, N. J.
Gegner, Paul J.....Barberton, Ohio
Gehlen, Carl.....New York, N. Y.
Gensberg, Aaron.....Odessa, Tex.
Gerlovich, C. Lewis..Houston, Tex.
German, Alfred...New York, N. Y.
Gernert, Marvin L.....Kingsport, Tenn
Gibbon, Anthony.....Tulsa, Okla.
Gibbons, Harry J.....Tulsa, Okla.
Gifford, Edmund W.....Milwaukee, Wis.
Gignoux, J. R., Los Angeles, Calif.
Gilbert, T. H....Los Angeles, Calif.
Gilliland, John L., Jr.....Denver, Colo.
Gilmore, Ernest A., Jr.....Wichita, Kan.
Givens, Allen T.....Monroe, La.
Glandon, G. O.....Tulsa, Okla.
Glasgow, Clarence O....Tulsa, Okla.
Glass, D. C.....Chicago, Ill.
Gleason, Alvin T....Shreveport, La.
Glenn, Denis....Wichita Falls, Tex.
Gleser, Sol M.....St. Louis, Mo.
Godard, H. P.....Kingston, Ontario, Canada
Godshalk, James B.....Philadelphia, Pa.
Godshall, J. Byron.....Easton, Pa.
Goetz, Alvin C.....Cincinnati, Ohio
Goheen, John L.....Mahwah, N. J.
Goins, Vernon D.....Oklahoma City, Okla.
Goit, Laurance E.....Los Angeles, Calif.
Goldkamp, Chris A.....San Diego, Calif.
Goldsby, Fred L....New York, N. Y.
Good, Donald Blake....Tulsa, Okla.
Goodall, R. A.....Ogallala, Neb.
Goodrich, C. R.....Fort Worth, Tex.
Goodwin, Carlton L., Portland, Me.
Gorden, C. D.....Katy, Tex.
Gordon, A. H.....Ogallala, Neb.
Gorman, L. J.....New York, N. Y.
Gosnell, Everett C...Cleveland, Ohio
Goudielock, Wm. B. O'Brien.....New York, N. Y.
Gow, James T.....Portland, Ore.
Gowans, Louis L...Honolulu, T. H.
Graber, Waldo E.....Liberal, Kan.
Grader, K. W.....Philadelphia, Pa.
Graham, D. W...Los Angeles, Calif.
Graham, Robert A....Lincoln, Neb.
Graham, S. B.....New York, N. Y.
Grassman, Herbert S...Chicago, Ill.
Grau, Vicente Massuet.....Barcelona, Spain
Graves, Colburn R.....Long Island, N. Y.
Graves, J. H.....Joinerville, Tex.
Graves, R. W.....Shreveport, La.
Gray, A. E., Long Island City, N. Y.
Gray, R. M.....Long Beach, Calif.
Greathouse, Glenn A.....Washington, D. C.
Grebe, H. A.....Houston, Tex.
Grebe, John J.....Midland, Mich.
Grebstad, Ernest H.....Los Angeles, Calif.
Greco, Edward C....Shreveport, La.
Green, M. C.....Wichita, Kan.
Green, W. A.....Jonesboro, Ark.
Green, Willis G., Los Angeles, Calif.
Greene, U. T.....Painesville, Ohio
Greenspan, Joseph....Danville, Ill.
Gregg, Harris T.....Houston, Tex.
Greve, Lyman F.....Chicago, Ill.
Gribble, Charles G., Jr.....Houston, Tex.
Griffin, H. K.....Meridian, Miss.
Griffith, Dean O.....Houston, Tex.
Griffith, T. E.....Houston, Tex.
Griggs, Henry P....Alexandria, Va.
Griswold, T. N...Ponca City, Okla.
Grizzard, Eugene H.....Los Angeles, Calif.
Grondal, B. J.....Belmont, Mass.
Groom, C. H., Jr.....Tulsa, Okla.
Gropp, Armin H....Gainesville, Fla.
Gross, Lewis...Corpus Christi, Tex.
Gross, W. F.....St. Louis, Mo.
Gruber, K. A.....New York, N. Y.
Guerry, William A., Red Bank, N. J.
Guinn, C. F.....Houston, Tex.
Gurney, W. B....Baton Rouge, La.
Guthrie, John M....Swissvale, Pa.

H

Haas, Charles A.....Houston, Tex.
Haas, D. Marshall...Baytown, Tex.
Haas, W. B.....Omaha, Neb.
Haase, Harold F....Milwaukee, Wis.
Hackerman, Norman...Austin, Tex.
Hackett, Albert Harold.....Caracas, Venezuela, S. A.
Haddad, Ibrahim S.....Beriut, Lebanon
Hadley, Raymond F.....Philadelphia, Pa.
Haering, Vera W.....Chicago, Ill.
Hageman, D. E.....Billings, Mont.
Hagemeier, Charles E.....Houston, Tex.
Hager, Frederick.....Elmira, Ontario, Canada
Hager, Karl F.....Fort Bliss, Tex.
Hagius, Karl S.....Colorado Springs, Colo.
Hahler, John J., Jr.....North Platte, Neb.
Hahn, A. H.....Tulsa, Okla.
Halbig, John J....Middletown, Ohio
Hale, William L., Brooklyn, N. Y.
Hall, Elwin B...Los Angeles, Calif.
Hall, Kenneth G.....Long Island City, N. Y.
Hall, Nathaniel.....Newark, N. J.
Hall, Paul.....Houston, Tex.
Hall, R. E.....Wilmington, Calif.
Hall, W. Quentin, Baton Rouge, La.
Halley, James W.....East Chicago, Ind.
Halsell, Hampton L.....Fayetteville, Ark.
Haltom, J. Myrl.....Dallas, Tex.
Hamilton, Archer B.....Hartford, Conn.
Hamilton, Hugh L.....Philadelphia, Pa.
Hamilton, J. S.....New Kensington, Pa.
Hamlin, Arthur W.....New York, N. Y.
Hammond, Milton B.....Edgeworth Sewickley, Pa.
Hamstead, A. C.....South Charleston, W. Va.
Hanes, Henry W., Jacksonville, Tex.
Hanger, K. H.....St. Louis, Mo.
Hanson, Melvin A.....Bloomington, Ill.
Harber, Thomas W.....Dallas, Tex.
Harbison, Dixon T.....Fort Worth, Tex.
Hardcastle, Coy A., El Dorado, Ark.
Harden, G. D....East Chicago, Ind.
Hardy, Ivan C.....Ottawa, Ontario, Canada
Hargroder, A. D., Lake Charles, La.
Harris, Jack W.....Houston, Tex.
Harris, John J.....Houston, Tex.
Harris, R. L.....Birmingham, Ala.
Harrison, James R...Newark, Ohio
Harrison, Scott J.....Tulsa, Okla.
Hart, James L...Bartlesville, Okla.
Hart, M. B.....Brookfield, Ill.
Hart, Porter.....Freeport, Tex.
Hart, R. P.....St. Louis, Mo.
Hartman, H. F.....Baytown, Tex.
Hartwick, Otto J.....Houston, Tex.
Harvey, C. C.....Baton Rouge, La.
Harvey, John M.....Tulsa, Okla.
Harvey, W. J.....Newark, N. J.
Hatch, George B....Pittsburgh, Pa.
Hatfield, Homer F...Allentown, Pa.
Hawke, David L...Brooklyn, N. Y.
Healey, Edward Lewis.....New York, N. Y.
Heath, John R.....Cleveland, Ohio
Hecht, Max.....Drexel Hills, Pa.
Heck, Stanley M.....Reading, Pa.
Heger, J. J.....Pittsburgh, Pa.
Heideman, William A.....East St. Louis, Ill.
Heil, Carl E.....Cleveland, Ohio
Heinemann, Gustave .....Corpus Christi, Tex.
Heinen, Lawrence E..Houston, Tex.
Heinzerling, Robert F.....Hasbrouck Heights, N. J.
Heitman, Talmage M., Jr.....Houston, Tex.
Heitzman, Eugene M.....Houston, Tex.
Helmbrecht, A. J., New York, N. Y.
Helmrath, Norman K.....Chicago Heights, Ill.
Hemphill, D. B.....Odessa, Tex.
Henderson, E. L...Shreveport, La.
Henderson, Mervin W.....Springfield, Mo.
Henderson, R. C.....London, Ontario, Canada
Henderson, W. Paul, Baltimore, Md.
Henderson, Walter A.....New York, N. Y.
Hendryx, John W...Baytown, Tex.
Henke, Robert H.....Brackenridge, Pa.
Henley, Don J....Port Neches, Tex.
Henry, Ernest L.....Houston, Tex.
Henry, R. E.....Longview, Tex.
Herndon, L. Kermit, Columbus, Ohio
Herringshaw, D. E.....Jackson, Mich.
Herstein, Frederick E.....Keasbey, N. J.
Herzler, Ralph E., Jr., Chicago, Ill.
Herzog, Max A.....Springfield, Mo.
Hess, Albert W....Philadelphia, Pa.
Hess, Fred E.....Fort Worth, Tex.
Hess, W. T.....New Orleans, La.
Heussner, Carl E.....Detroit, Mich.
Heverly, L. F.....New York, N. Y.
Hewitt, Harry N.....Montreal, Quebec, Canada
Heye, B. F.....Corpus Christi, Tex.
Hibbs, Don B.....Kansas City, Mo.
Hickethier, Carlos F.....Republic, Argentina, S. A.
Hickey, Robert Percy.....Trenton, Mich.
Hieronymus, Frantz M., Tulsa, Okla.
Higburg, Wm....Indianapolis, Ind.
Higdon, Victor E.....Wilmington, Calif.
Higgins, Edward J.....East Orange, N. J.
Higgins, Frank T.....Long Beach, Calif.
Higgins, J. D., Jr.....Fort Worth, Tex.
Higgins, Waldo W....Kankakee, Ill.
Hill, Leonard C.....Hastings, Neb.
Hill, Roy W.....Fort Belvoir, Va.
Himmler, Alden C., Hollywood, Md.
Hinchman, William H. D.....Detroit, Mich.
Hinckley, Arthur T.....Niagara Falls, N. Y.
Hinds, Julian...Los Angeles, Calif.
Hinkle, Geo. S., Jr...Houston, Tex.
Hirshfeld, James F...Detroit, Mich.
Hiskey, D. R...Los Angeles, Calif.
Hodson, Fred W.....Houston, Tex.
Hoiberg, Arnold J., El Dorado, Ark.
Holcomb, William D...Chicago, Ill.
Holcombe, Tom L., Shreveport, La.
Holler, Homer D.....Washington, D. C.
Holloway, J. A.....Edna, Tex.
Holm, Emil G.....Houston, Tex.
Holmberg, Emil G....Linden, N. J.
Holmberg, M. E., Bartlesville, Okla.
Holmes, Laird E.....Robinson, Ill.
Holsteyn, Derk.....Houston, Tex.
Holt, James B.....Carlsbad, N. M.
Holtman, Clemens W.....Louisville, Ky.
Honecker, Walter C.....Indianapolis, Ind.
Hookanson, Kenneth G.....Morton Grove, Ill.
Hopkins, Arthur James.....Melbourne, C. 1, Australia
Hopkins, John R....Denver, Colo.
Hopkins, W. H.....Houston, Tex.
Hopper, Edward W.....Pittsburgh, Pa.
Horne, Albert N...Beirut, Lebanon
Horner, Richard H.....Jersey City, N. J.
Horst, Ralph L., Jr.....New Kensington, Pa.
Horstman, W. G.....Atlanta, Ga.
Hort, Percy.....Philadelphia, Pa.
Horton, James B....Bethlehem, Pa.
Horvath, Louis.....Cleveland, Ohio
Hosford, Harry W., Cleveland, Ohio
Hounsell, Wm. H.....Refugio, Tex.
Howard, Owen G.....Toledo, Ohio
Howell, John C., Maplewood, N. J.
Howell, Lynn D., Lake Charles, La.
Howell, R. P., San Francisco, Calif.
Hoxeng, Raymond B.....Cleveland, Ohio
Huber, Karl E...Long Beach, Calif.
Huddleston, Wm. E.....Bartlesville, Okla.
Hudock, George W.....Park Forest, Ill.
Hudson, George H., Jr.....Los Angeles, Calif.
Huff, William R.....Morgantown, W. Va.
Hughes, Charles F.....Port Arthur, Tex.
Hughes, D. E., Jr.....Houston, Tex.
Hughes, H. D.....Dallas, Tex.
Hughes, H. M.....Tulsa, Okla.
Hugo, L. A.....Bartlesville, Okla.
Hull, George C., Jr...Newark, N. J.
Hummon, C. Gerald.....Kansas City, Mo.
Hunt, A. J.....Odessa, Tex.
Hunter, Felix A.....Sweeny, Tex.
Hunter, J. N., Jr.....Tulsa, Okla.
Hunter, Ralph M....Midland, Mich.
Hunter, Wesley L.....Newark, Ohio
Huntley, Harold R.....New York, N. Y.
Hur, J. James....Philadelphia, Pa.
Hurley, E. T.....Montreal, Quebec, Canada
Hurst, Ralph.....Jackson, Miss.
Hurst, S.....London, England
Hurtado, J. R.....Caracas, Venezuela, S. A.
Hurtgen, Archibald, Louisville, Ky.
Hustead, B. G.....Kilgore, Tex.
Huston, Kenneth M., Baltimore, Md.
Hutchcraft, D. K.....Olean, N. Y.
Hutchinson, Carroll O., Chicago, Ill.
Hutchinson, Gilbert E.....Bridgeport, Conn.
Hutzler, George J.....Philadelphia, Pa.

I

Iles, John T.....Harrisburg, Pa.
Ingels, G. R.....Houston, Tex.
Ireland, L. G.....New Orleans, La.
Irvine, G. O.....Houston, Tex.
Irwin, C. A.....Brownsville, Tex.
Isherwood, J. H.....Port Allegany, Pa.

J

Jackson, B. R.....New York, N. Y.
Jackson, C. M.....Newark, N. J.
Jackson, Hedley V.....Port Neches, Tex.
Jackson, J. Harry..Columbus, Ohio
Jackson, Maynard H...Tulsa, Okla.
Jackson, Russell.....Phoenix, Ariz.
Jacobson, Murray.....Watertown, Mass.
Jacobson, Ralph N.....San Francisco, Calif.
James, H. E.....Memphis, Tenn.
James, Jay R.....Tulsa, Okla.
James, Paul W.....Syracuse, N. Y.
Janny, Louis.....Paris, France
Janssen, W. S.....Texas City, Tex.
Jednacz, John E...Philadelphia, Pa.
Jeffares, George M....Atlanta, Ga.
Jehu, Llewellyn, Jr.....Lachine, Quebec, Canada
Jekot, Chester M.....Chicago, Ill.
Jelen, Frederic C...Syracuse, N. Y.
Jelinek, F. R.....Port Neches, Tex.
Jenkins, Clark L.....Houston, Tex.
Jenkins, Vance N.....Wilmington, Calif.
Jenner, William C.....Cleveland, Ohio
Jensen, Claude H.....Glassport, Pa.
Jensen, M. G.....Toledo, Ohio
Jensen, O. L.....Oak Park, Ill.
Jessen, Frank W.....Austin, Tex.
Johannes, E. Gent...St. Louis, Mo.
Johnson, A. G.....Omaha, Neb.
Johnson, Dewey W....Chicago, Ill.
Johnson, Earl A. N., Shelton, Wash.
Johnson, Elmer A....Lincoln, Calif.
Johnson, Gerald M., Ft. Worth, Tex.
Johnson, J. F., Jr., Zionsville, Ind.
Johnson, Russell K.....New York, N. Y.
Johnson, Thomas E., Freeport, Ill.
Johnson, W. A.....Melbourne, C. 1, Vic. Australia
Johnson, Wayne A...Houston, Tex.
Johnson, Wm. W.....Port Arthur, Tex.
Johnston, Glenn E.....Coatesville, Pa.
Johnston, Howard E.....New York, N. Y.
Johnston, J. Flynn....Atlanta, Ga.
Jones, Charles C...Philadelphia, Pa.
Jones, David T.....North Hollywood, Calif.
Jones, Elmer H., Los Angeles, Calif.
Jones, G. C.....Jackson, Miss.
Jones, R. M.....Chicago, Ill.
Jones, William E.....Dixon, Ill.
Joplin, J. L.....Houston, Tex.
Jopp, J. M.....La Tuque, Quebec, Canada
Jordan, Harry E.....New York, N. Y.
Jordan, Raymond C.....Shreveport, La.
Jorgensen, Roy C.....Freeport, Tex.
Joy, Austin S...Wilmington, Calif.
Judah, Melvin A.....Houston, Tex.
Jurs, Peter C.....Berkeley, Calif.
Juster, Maurice W.....East Chicago, Ind.

K

Kahler, H. Lewis, Philadelphia, Pa.
Kahn, Frank.....Philadelphia, Pa.
Kaim, Fred J....Minneapolis, Minn.
Kalhauge, Viggo M.....Chicago, Ill.
Kamps, Julius M...Pittsburgh, Pa.
Karnisky, Benny.....East Chicago, Ind.
Karraker, E. L....Waltham, Mass.
Kartinen, Ernest O.....Los Angeles, Calif.
Kaster, J. W.....Tulsa, Okla.
Kaszynski, John F....Chicago, Ill.
Kauffman, David S.....Independence, Kan.
Kaufman, L. W.....Mansfield, Ohio
Kaufmann, D. W....Buffalo, N. Y.
Kavenaugh, J. A.....Los Angeles, Calif.
Kean, E. E., Jr.....Columbus, Miss.
Keane, C. C.....Kansas City, Mo.
Keaney, J. C.....Pittsburgh, Pa.
Keeling, Harry J.....Los Angeles, Calif.
Keepers, Guy S.....Enid, Okla.
Keiter, Irvin L....Philadelphia, Pa.
Keith, Cecil S...Grand Prairie, Tex.
Kellam, G. D.....Calgary, Alberta, Canada
Keller, Albert Freed, Baltimore, Md.
Keller, Ralph W.....Colorado City, Tex.
Keller, Richard M.....Philadelphia, Pa.
Keller, W. H.....St. Louis, Mo.
Kelley, V. A.....Houston, Tex.
Kelly, R. W.....Tulsa, Okla.
Kelly, Thomas F. P., Houston, Tex.
Kellogg, Lucius Andrew.....Syracuse, N. Y.
Kemp, James T.....San Francisco, Calif.

Kemper, E. O.....Odessa, Tex.
Kendall, Verner V...Pittsburgh, Pa.
Kendrick, J. L.....Kenner, La.
Kennedy, Harvey T.....College Station, Tex.
Kennedy, Ted.....Detroit, Mich.
Kerns, Everette E...Cleveland, Ohio
Ketcham, Brower .....San Francisco, Calif.
Kettron, Henry P.....MacComb, Ill.
Kiefer, George C., Brackenridge, Pa.
Kimbro, A. M.....Houston, Tex.
Kimmel, Albert L.....Gainesville, Fla.
King, Frederic C., Torrance, Calif.
King, Glenn W.....Houston, Tex.
Kinnear, R. C....Port Neches, Tex.
Kipp, E. M.....New Orleans, La.
Klauber, L. M....San Diego, Calif.
Kleber, John P.....Pittsburgh, Pa.
Klein, Fred. M....New York, N. Y.
Klein, Meyer.....Houston, Tex.
Kleinheksel, S.....Plainfield, N. J.
Klever, Charles F.....Omaha, Neb.
Klinger, Lloyd L.....Wisconsin Rapids, Wis.
Klinger, O. C.....Bayonne, N. J.
Kluender, Arnold F....Chicago, Ill.
Knapp, Frederick F.....Glendive, Mont.
Knight, C. A.....Beaumont, Tex.
Knopp, Harold P....Oakland, Calif.
Knowlton, A. E...New York, N. Y.
Knowlton, Drexel R...Avenal, Calif.
Knudsen, H. A.....Oakland, Calif.
Koehler, W. A.....Morgantown, W. Va.
Koenig, E. A.....Shreveport, La.
Koester, H. F.....New York, N. Y.
Kolff Van Oosterwijk, A. R.....Amsterdam, Holland
Kolzow, Clarence R....Chicago, Ill.
Kopetz, Geo. E.....Pittsburgh, Pa.
Kopita, Robert....New York, N. Y.
Kopp, C. H....Oklahoma City, Okla.
Kosik, John A., Chattanooga, Tenn.
Krell, Abraham J.....Dallas, Tex.
Kretschmer, William J.....Columbus, Ohio
Krikscus, Paul, Jr.....Los Angeles, Calif.
Kropf, Victor J.....East Pittsburgh, Pa.
Krueger, Forrest J.....New York, N. Y.
Krueger, Jess J.....Beatrice, Neb.
Kruger, R. E.....Rochester, N. Y.
Kuehnle, C. A., Jr...Baltimore, Md.
Kuhlmann, Frank H., St. Louis, Mo.
Kuhn, Cyril D.....Houston, Tex.
Kuhn, Robert J...New Orleans, La.
Kulman, Frank E., New York, N. Y.
Kuniansky, I.....Atlanta, Ga.

L

Lachmund, D. O.....Newark, N. J.
Lacy, J. Glen....South Gate, Calif.
Ladenburg, Kurt .....Lawrenceburg, Ind.
Lain, Albert Eugene.....Colorado City, Tex.
Lain, George D...New York, N. Y.
Lambert, Frank J., Jr.....Oak Ridge, Tenn.
Lamond, John K...Philadelphia, Pa.
Lane, B. S.....Kalamazoo, Mich.
Lane, Russell W.....Urbana, Ill.
Lang, Franklin...New York, N. Y.
Langhus, Louis.....Lincoln, Neb.
LaQue, F. L.....New York, N. Y.
Larrabee, C. P.....Vandergrift, Pa.
Larsen, Robert L.....Casper, Wyo.
Larson, Thurston E....Urbana, Ill.
Laster, Gaines.....Tulsa, Okla.
Lastrapes, Richard L.....Beaumont, Tex.
Lattin, Benton Calver.....Mt. Vernon, N. Y.
Lavery, C. A.....Tulsa, Okla.
Law, John E.....Chicago, Ill.
Law, R. J.....Toronto, Canada
Lawlor, E. W.....Pittsburgh, Pa.
Lawrence, R. E., Jr., Tarboro, N. C.
Layne, Harold B.....Colorado City, Tex.
Leary, John D., Corpus Christi, Tex.
Leas, A. Robert..Washington, D. C.
LeBlanc, Roland L., Maplewood, La.
Ledbetter, Buford P.....Corpus Christi, Tex.
Lederer, Lewis M., Cincinnati, Ohio
Ledford, Raymond F...Chicago, Ill.
Leedom, Laurie M.....Bloomfield, N. J.
Lefebvre, Fabian J...Newark, N. J.
Lehmann, F. A...Oak Ridge, Tenn.
Lehmann, Joseph A.....New York, N. Y.
Lemay, Jack E....Pittsburgh, Pa.
Lembcke, Richard E., Tallant, Okla.
Lennox, William R.....Aruba, N. W. I.
Leonardon, Eugene Gilbert.....Houston, Tex.
Leonhard, Frederick J.....Cleveland, Ohio
Lester, C. B.....St. Louis, Mo.
Lester, L. B....Los Angeles, Calif.
Levert, Wm. F.....Shreveport, La.
Levinson, Irving S.....Milwaukee, Wis.
Levy, David Henry.....Dallas, Tex.
Lewis, L. G.....Midland, Tex.
Lewis, Robert H.....Fort Lauderdale, Fla.
Liebhafsky, Herman A.....Schenectady, N. Y.
Liebman, Arno J....Pittsburgh, Pa.
Liesenbein, Robert P.....South Amboy, N. J.
Liggett, Ernest J.....Tulsa, Okla.
Ligon, John R....Fort Worth, Tex.
Lima, D. O...Oklahoma City, Okla.
Lindberg, R. I.....Harvey, Ill.
Lindemann, Ervin .....Minneapolis, Minn.
Lindsay, Joseph E.....Johnstown, Pa.
Lineback, George A.....Cincinnati, Ohio
Lingle, Robert J.....Houston, Tex.
Lippenberger, D. V.....Cleveland, Ohio
Lithgow, James, Los Angeles, Calif.
Littreal, Wm. Bernard.....Salt Lake City, Utah
Livengood, Robert G.....Shreveport, La.
Lobley, F. A.....Elkhart, Ind.
Lobo, Humberto, Jr.....Monterrey, N. L., Mexico
Lobry De Bruyn, C. A.....Delft, Holland
Lockwood, C. J.....Beaumont, Tex.
Lockwood, C. K.....Montreal, Quebec, Canada
Lockwood, Luther E...Maywood, Ill.
Loeffler, John Edward.....Houston, Tex.
Loeffler, William J.....Providence, R. I.
Logan, Kirk H...Washington, D. C.
Lomax, O. Q.....Houston, Tex.
Long, Dan P.....Amarillo, Tex.
Longfield, C. M.....Melbourne, Victoria, Australia
Loos, De Lasso.....Midland, Tex.
Lopata, Stanley L....St. Louis, Mo.
Lopez, Eugene R., New York, N. Y.
Lo'Prete, Jack H.....Detroit, Mich.
Loucks, Charles M., Cleveland, Ohio
Lovelady, H. A.....Tulsa, Okla.
Loudenback, Clyde I....Chicago, Ill.
Love, Frank H.....Dallas, Tex.
Lovell, Odus W., Jr.....Shreveport, La.
Lowe, Marvin E.....Bogota, Colombia, S. A.
Lowe, R. A., Maracaibo, Venezuela
Lowther, G. B.....St. Louis, Mo.
Luce, Walter A.....Dayton, Ohio
Luger, Karl E.....Houston, Tex.
Lundy, Daniel A.....Los Angeles, Calif.
Lungren, E. E.....Chicago, Ill.
Lutjens, Fred H...Sioux City, Iowa
Lynch, Robert H., Philadelphia, Pa.
Lynch, William H....St. Louis, Mo.
Lynes, Wilson.....Rome, N. Y.

M

MacAdam, Walter K.....New York, N. Y.
MacArthur, J. G....Pittsburg, Kan.
MacCollum, Donald R.....Rochester, N. Y.
MacDonald, Frank P...Chicago, Ill.
MacGregor, Alfred H.....Webster Groves, Mo.
Mach, Walter W.....Wichita, Kan.
Machado, Oscar .....Caracas, Venezuela, S. A.
MacKenzie, James T.....Birmingham, Ala.
MacRoberts, D. T...Shreveport, La.
Magoffin, Linn E.....National City, Calif.
Madden, R. C.....Fontana, Calif.
Mahoney, E. J., Jr.....Mt. Pleasant, Mich.
Main, Merrill M.....Chicago, Ill.
Maitland, T. J.....New York, N. Y.
Malcom, V. V.....Lockland Cincinnati, Ohio
Maloney, Richard W.....Los Angeles, Calif.
Malouf, E. E., Salt Lake City, Utah
Mange, Clarence E...St. Louis, Mo.
Manley, Harold W....Tulsa, Okla.
Mann, L. D.....Lake Charles, La.
Manning, John A., Jr.....Texas City, Tex.
Maradudin, Alexei P.....El Segundo, Calif.
Markle, M. G.....Oak Park, Ill.
Marlin, Donald H...Pittsburgh, Pa.
Marrinan, J. W....Pittsburgh, Pa.
Marshall, Dwight..New York, N. Y.
Martin, Arthur R., Milwaukee, Wis.
Martin, D. S....Indianapolis, Ind.
Martin, F. J.....St. Louis, Mo.
Martin, Paschal.....Chicago, Ill.
Martin, Robert C.....Atlanta, Ga.
Mary, E. J.....McPherson, Kan.
Marx, Paul F.....Bradford, Pa.
Mason, John F., Jr.....New York, N. Y.
Mastroberte, Joseph .....New York, N. Y.
Mathers, W. D....Ridgefield, N. J.
Matheson, E. E....Pittsburgh, Pa.
Matson, Eugene M.....Chicago, Ill.
Matthews, Norman A...Elyria, Ohio
Matthews, R. F.....Tulsa, Okla.
Mauney, L. M.....Tulsa, Okla.
Maurer, Robert F., Wood River, Ill.
Mauzy, Harry Lincoln.....Houston, Tex.
Mavor, James E.....Houston, Tex.
May, Thomas P...New York, N. Y.
Mayer, William J., Baltimore, Md.
Mayes, H. B.....Houston, Tex.
Mayhan, W. Alvin, Little Rock, Ark.
Mayne, Paul J.....Opelousas, La.
Mayo, E. E...San Francisco, Calif.
McArthur, Ralph F.....Huntington Park, Calif.
McCall, Richard H...Pearland, Tex.
McCann, Sidney W.....Rochester, N. Y.
McCarthy, Robert A....Dallas, Tex.
McCaslin, Kenneth M.....South Gate, Calif.
McCauley, E. D...Birmingham, Ala.
McClenhan, W. T.....Chicago, Ill.
McClintock, Robt. D.....Colorado Springs, Colo.
McCloud, Dwite M.....La Habra, Calif.
McClughan, Joseph...Houston, Tex.
McComb, Geo. B.....St. Louis, Mo.
McConomy, Henry F.....Philadelphia, Pa.
McCormick, Lawrence O.....Baltimore, Md.
McCullough, Harold M.....Flushing, N. Y.
McCumber, Ralph H.....Rochester, N. Y.
McDaniel, John P.....Houston, Tex.
McDonald, Herschel C.....San Antonio, Tex.
McDonald, Hugh J.....Chicago, Ill.
McDonald, T. B.....Shreveport, La.
McDuffie, Roy O...Cincinnati, Ohio
McElhatton, Francis J.....Kansas City, Mo.
McFarland, Rolland, Jr.....Chicago, Ill.
McGary, S. U.....Houston, Tex.
McGee, Herbert S.....Evanston, Ill.
McGill, Robert L.....Tulsa, Okla.
McGowan, James A.....Los Angeles, Calif.
McGrue, W. M.....Brentwood, Mo.
McGuffy, E. L.....Shreveport, La.
McIlrath, Samuel W.....Painesville, Ohio
McIntosh, Russell W.....San Francisco, Calif.
McIntyre, G. H....Cleveland, Ohio
McKenzie, T. Curtis.....Dearborn, Mich.
McKeown, Thomas S...Chicago, Ill.
McKee, Arvil B.....New Kensington, Pa.
McLaren, James..Oak Ridge, Tenn.
McLeod, Raymond H...Chicago, Ill.
McMahon, George F....Chicago, Ill.
McMillan, William A., Jr.....Houston, Tex.
McMullin, H. L.....Dallas, Tex.
McNeese, C. L.....Houston, Tex.
McNulty, Frank E.....Tulsa, Okla.
McPherson, R. C.....Edmonton, Alberta, Canada
McRaven, C. H., Cocoli, Canal Zone
McSparran, W. G.....Los Angeles, Calif.
McWaters, Raymond J.....Long Island City, N. Y.
Meacher, H. John.....Chicago, Ill.
Mead, William J.....Army Chemical Center, Md.
Means, Ben H.....Houston, Tex.
Mears, Robert B....Pittsburgh, Pa.
Meek, J. Gordon.....Lubbock, Tex.
Meier, A. O.....New York, N. Y.
Meigs, W. H., Oklahoma City, Okla.
Mellon, P. D.....Calgary, Alberta, Canada
Mendive, Anthony J., Houston, Tex.
Mendizza, August .....Murray Hill, N. J.
Mengel, Arthur C.....Schenectady, N. Y.
Mercer, C. L.....Houston, Tex.
Merrill, Timothy W.....Bridgeville, Pa.
Meyer, Frederick R.....New Haven, Conn.
Meyer, Walter.....St. Louis, Mo.
Michael, Lewis E.....Dayton, Ohio
Michaud, M. L...Wilmington, Calif.
Miles, John A.....Diablo Heights, Canal Zone
Miller, Calvin A....Springfield, Ill.
Miller, Carl F., Jr.....Philadelphia, Pa.
Miller, Frank H., Jr.....Louisville, Ky.
Miller, George M.....Louisville, Ky.
Miller, Harry J.....Chicago, Ill.
Miller, M. C...W. Englewood, N. J.
Miller, Pat H.....Shreveport, La.
Miller, Paul Thomas..Houston, Tex.
Miller, Ralph D.....Pittsburg, Kan.
Miller, Ross F....Emeryville, Calif.
Miller, William J.....Chicago, Ill.
Mills, Earnest J.....Benton, La.
Mills, Geo. A...Corpus Christi, Tex.
Mills, Lester D., Jr., Cleveland, Ohio
Miltner, Donald E....Wichita, Kan.
Mims, Lewis.....Tulsa, Okla.
Minor, Alton F.....Jackson, Miss.
Mitchell, E. B.....Houston, Tex.
Mitchell, Francis H.....Los Angeles, Calif.
Mitchell, Jefferson W.....McPherson, Kan.
Mitchell, Leo S.....Pasadena, Tex.
Mitchell, Marvin G.....Tulsa, Okla.
Mitchell, N. W..Waterbury, Conn.
Modjeska, R. Scott.....Chicago, Ill.
Moe, John L.....New York, N. Y.
Moehrl, Kenneth E., Memphis, Tenn.
Moffatt, Thomas S., Jr.....Corpus Christi, Tex.
Moffett, J. L.....Lima, Ohio
Moffitt, John H.....Hugoton, Kan.
Moir, B. E.....Dallas, Tex.
Moncrief, R. S.....Shreveport, La.
Monson, Louis T.....Los Angeles, Calif.
Montel, Joseph I...New York, N. Y.
Moore, Albert E....Camden, N. J.
Moore, H. W.....Tulsa, Okla.
Moore, Jack M.....Midland, Tex.
Moore, Laban T...Catlettsburg, Ky.
Moore, Roy W.....Brooklyn, N. Y.
Moran, W. T.....Houston, Tex.
Morgan, C. L.....Houston, Tex.
Morie, Fred C.....St. Louis, Mo.
Morris, Clarence S.....Los Angeles, Calif.
Morris, H. E.....Texas City, Tex.
Morrison, Barclay.....Union N. J.
Morrison, D. Benjamin, Gary, Ind.
Morrison, E. G.....Austin, Tex.
Morrow, Orville E.....San Francisco, Calif.
Morse, Arley Edwin...Chicago, Ill.
Morse, Robert E...New York, N. Y.
Morton, Byron B...New York, N. Y.
Moseley, E. L.....Houston, Tex.
Mosher, Malcolm.....Quincy, Mass.
Mount, W. R.....Edmonton, Alberta, Canada
Moyar, Robert E.....Toronto, Ontario, Canada
Moyer, George H.....Chicago, Ill.
Moyle, M. W.....Rosita, Coahhuila, Mexico
Mudd, O. C.....Houston, Tex.
Muery, Sam J., Jr.....Port Sulphur, La.
Muller, Herman, Jr.....New York, N. Y.
Mullin, Grover E., Philadelphia, Pa.
Mulvaney, E. J., Jr., Pasadena, Tex.
Mundt, H. W.....Diablo Heights, Canal Zone
Munger, C. G.....South Gate, Calif.
Munneke, A. S.....Shawnee, Okla.
Murray, Christopher A.....Nederland, Tex.
Murray, Herman D...Midland, Tex.
Murrey, O. E.....Tulsa, Okla.
Muschenheim, Harry, Jr.....Philadelphia, Pa.
Musgrave, John R.....Joplin, Mo.
Myers, G. Frank....Beaumont, Tex.
Myers, W. R.....Wilmington, Del.

N

Naschke, John H.....Houston, Tex.
Nash, William F., Jr.....Alhambra, Calif.
Neal, James L.....Dallas, Tex.
Nee, John W., Corpus Christi, Tex.
Nee, Robert M.....Chicago, Ill.
Neher, Frank H...New York, N. Y.
Neilon, C. R.....Houston, Tex.
Neipp, Howard S., Kansas City, Mo.
Nelson, Alan C.....Beruit, Lebanon
Nelson, F. M.....Houston, Tex.
Nelson, H. Lloyd, Burlington, N. J.
Nelson, Harley A., Palmerton, Pa.
Nelson, Loyd B.....Cushing, Okla.
Nelson, Otis A.....Houston, Tex.
Neprude, E. N., Minneapolis, Minn.
Nerhood, H. Elmer.....Akron, Ohio
Neuhaus, Richard....Buffalo, N. Y.
Nevill, Richard A., Ft. Worth, Tex.
Newport, John J.....Freeport, Tex.
Newton, William E.....Lakewood, Ohio
Nicholls, P. E.....Galveston, Tex.
Nichols, Laurie E.....Oak Park, Ill.
Nicholson, C. T.....Buffalo, N. Y.
Nicholson, J. C.....Tulsa, Okla.
Nicholson, Jay T.....Los Angeles, Calif.
Nickerson, James G...Houston, Tex.
Nicolson, H. W.....Newark, N. J.
Nielsen, Claudius....Detroit, Mich.
Nielsen, Norman A.....Wilmington, Del.
Niwao, Jitsuo, Hilo, Hawaii, T. H.
Nixon, James A.....New Haven, Conn.
Nixon, T. H.....Lake Charles, La.
Noelle, Calvin D....Park Ridge, Ill.

Nolan, James C., Los Angeles, Calif.
Nolan, Vincent J., New York, N. Y.
Nole, Vito F.....Waterbury, Conn.
Noppel, E. P.....New York, N. Y.
Norberg, H. A.....Tulsa, Okla.
Nordquist, Howard O.....St. Louis, Mo.
Noreen, Olaf S.....Charlotte, N. C.
Norris, J. M....Wichita Falls, Tex.
Northup, Maynard S.....Roselle Park, N. J.
Norton, Harry A...Kansas City, Mo.
Norwood, Vincent M.....Petrolia, Ontario, Canada
Noser, W. P.....Houston, Tex.
Noyes, A. P.....Kilgore, Tex.
Nuezel, E. F.....Cincinnati, Ohio

O

O'Brien, Harold C., Jr.....Blawnox, Pa.
O'Brien, H. L., East Chicago, Ind.
O'Brien, Paul S., Baton Rouge, La.
O'Brien, T. W.....Jackson, Mich.
O'Dell, C. R.....Odessa, Tex.
Odell, L. B.....Houston, Tex.
Oechsle, Robert W.....Philadelphia, Pa.
Ogburn, H. R.....Marshall, Tex.
Ohrt, Frederick...Honolulu, Hawaii
O'Keefe, John F...New York, N. Y.
O'Leary, F. J., Beverly Hills, Calif.
Olive, Marion J.....Shreveport, La.
Oliver, J. Paul.....Cleveland, Ohio
Olson, G. R.....Shreveport, La.
Olson, Theodore W.....Geneseo, Ill.
O'Mara, Fred B.....Dallas, Tex.
Oravetz, Julius A.....Racine, Wis.
Orlins, Martin A....Millbrae, Calif.
Orr, C. M.....Houston, Tex.
Osborn, Oliver.....Freeport, Tex.
Ott, Lawrence H., South Gate, Calif.
Ott, Robert J.....Philadelphia, Pa.
Oxley, George W...Elizabeth, N. J.

P

Pace, Anderson, Jr.....Chicago, Ill.
Page, Glenn I.....Tulsa, Okla.
Paige, Henry.....Brooklyn, N. Y.
Palmer, James G....Houston, Tex.
Palmquist, W. W...Cleveland, Ohio
Pape, W. Howard...Houston, Tex.
Park, Paul S., Jr., Pittsburgh, Pa.
Parker, Ivy M.....Bremen, Ga.
Parker, Marshall E., Jr.....Houston, Tex.
Parnell, H. S.....Jackson, Miss.
Parnell, John B., New Castle, Del.
Parr, MacGregor A...Houston, Tex.
Parran, J. Harold...Baltimore, Md.
Parson, R. A.....Hammond, Ind.
Partington, Sydney...Detroit, Mich.
Patrick, George M....Houston, Tex.
Patterson, Bryan.....Salt Lake City, Utah
Patterson, M. Kingsley.....Minneapolis, Minn.
Paul, Robert J.....Cincinnati, Ohio
Payne, Harrison S.....San Francisco, Calif.
Payne, Paul B....Indianapolis, Ind.
Payson, Peter.....Harrison, N. J.
Payton, Victor J.....Chicago, Ill.
Peabody, A. W.....Jackson, Miss.
Pearson, E. T.....Maplewood, N. J.
Pearson, J. M., Newton Square, Pa.
Pecore, Albert E.....Houston, Tex.
Peifer, Norman P., Pittsburgh, Pa.
Peifer, Richard H., Heidelberg, Pa.
Peirce, Walter A.....Racine, Wis.
Pellegrino, Frank M.....Frankford, Philadelphia, Pa.
Pelton, Charles H.....Clinton, Iowa
Pennington, Louis E.....Los Angeles, Calif.
Penske, J. H., Jr., Cleveland, Ohio
Perier, Claude H.....Los Angeles, Calif.
Perkins, C. L.....El Paso, Tex.
Perkins, George.....Louisville, Ky.
Perkins, Wendell L.....New York, N. Y.
Permar, Philip H., Wilmington, Del.
Perrault, Lewis.....Tulsa, Okla.
Perry, Joe Reddell....El Paso, Tex.
Perry, Russell I.....Chicago, Ill.
Peterkin, Don W.....Chicago, Ill.
Peters, E. Donald..Cleveland, Ohio
Peters, Fred P....New York, N. Y.
Peters, Ralph C., Philadelphia, Pa.
Petersen, Lowell W....Chicago, Ill.
Peterson, A. J.....Chicago, Ill.
Peterson, F. P., Jr.....Corpus Christi, Tex.
Peterson, John C.....Gibsonia, Pa.
Pettee, Allen D.....Perth Amboy, N. J.
Pettibone, John S.....Philadelphia, Pa.
Pettijohn, Dale S....Burrton, Kan.
Pettyjohn, A. R...Texas City, Tex.
Pettyjohn, E. S.....Chicago, Ill.
Pfeiffer, Milton J...Cincinnati, Ohio
Pfrehm, R. H.....Houston, Tex.
Phelps, H. S.....Philadelphia, Pa.
Phelps, Samuel C.....Tulsa, Okla.
Phillians, T. F...Los Angeles, Calif.
Phillips, Cecil, Jr....Baytown, Tex.
Phillips, Edwin H....Oak Park, Ill.
Phillips, James H....Alliance, Ohio
Phipps, Harry K.....Wichita, Kan.
Picarazzi, Joseph J.....Lake Charles, La.
Pickens, Andrew T.....East St. Louis, Ill.
Pickering, Harry S.....Opa-Locka, Fla.
Pickrell, David D.....Ranger, Tex.
Pierce, Robert R., Philadelphia, Pa.
Pietrzak, Aloysius J.....Philadelphia, Pa.
Pike, Donald B.....Boston, Mass.
Pinner, W. L.....Detroit, Mich.
Pirsh, Edward A., New York, N. Y.
Pittman, Charles U.....Westfield, N. J.
Pittman, James H., Jr., Odessa, Tex.
Pittman, William G.....Hackensack, N. J.
Place, George W., New York, N. Y.
Plant, A. Morton.....New Haven, Conn.
Platz, E. H., Jr.....Lebanon, Pa.
Ploederl, F. J.....Hamilton, Ohio
Plog, Charles B., New York, N. Y.
Pogacar, C. F.....Pittsburgh, Pa.
Pokorny, Jerome J., Cleveland, Ohio
Polhamus, John R.....Corpus Christi, Tex.
Pollard, T. A.....Dallas, Tex.
Pollock, Bill..Corpus Christi, Tex.
Pollock, L. V.....Birmingham, Ala.
Polston, J. R.....Tulsa, Okla.
Pomeroy, Richard..Pasadena, Calif.
Ponder, Thomas C...Maplewood, La.
Pool, John L.....Dallas, Tex.
Pope, Robert.....New York, N. Y.
Porras, Jesus A.....Monterrey, N. L., Mexico
Porter, Cover C.....Lufkin, Tex.
Post, J. H. G., The Hague, Holland
Potteiger, William I., St. Louis, Mo.
Pourbaix, M. J....Brussels, Belgium
Powell, Edwin B....Boston, Mass.
Powell, Sheppard T., Baltimore, Md.
Powers, S. J....East Newark, N. J.
Powers, William J., Coatesville, Pa.
Pracy, George W.....San Francisco, Calif.
Prange, Frederick A.....Bartlesville, Okla.
Pratt, Ward E.....Harrison, N. J.
Pray, H. A.....Columbus, Ohio
Prescott, Joseph....Cleveland, Ohio
Presley, Maurice C.....Waterbury, Conn.
Price, David W...Waterbury, Conn.
Price, Marion E.....Denver, Colo.
Price, Walter J.....Houston, Tex.
Priestley, Henry L.....New York, N. Y.
Pringle, George H.....Chillicothe, Ohio
Prior, Joseph E., Paulsboro, N. J.
Pritchett, Edward C....Atlanta, Ga.
Procter, Bryant S., Jr.....Cleveland, Ohio
Proskowitz, Seymour, Houston, Tex.
Prutton, C. F.....Baltimore, Md.
Pullen, P. T.....Shreveport, La.
Purdy, D. F....Long Beach, Calif.
Purton, T. A., Salt Lake City, Utah
Purvis, Frank...San Antonio, Tex.
Putnam, Joseph F.....Richmond, Calif.
Pyeatt, F. E., Jr.....Tulsa, Okla.
Pyles, Russell.....Olean, N. Y.
Pyott, William T...Kansas City, Mo.

Q

Quelch, G. C., Jr.....Ormond Beach, Fla.

R

Radcliffe, Thomas Drew.....Evanston, Ill.
Radovich, Frank.....Huntington Park, Calif.
Raifsnider, Philip J.....Emeryville, Calif.
Raigorodsky, Paul M.....Houston, Tex.
Rainey, John B.....Houston, Tex.
Raith, W. H.....St. Louis, Mo.
Rall, Richard A., Jr.....Los Angeles, Calif.
Ramirez, Ernest P.....Chicago, Ill.
Randolph, A. F.....Newark, N. J.
Range, E. C.....Atlanta, Ga.
Rankin, Elbert L.....Corpus Christi, Tex.
Ransom, R. A....Washington, D. C.
Ranta, Leo G.....Chicago, Ill.
Raphael, William.....Boston, Mass.
Rapp, Harry E.....Pittsburgh, Pa.
Rask, Morris L.....Shaker Heights, Ohio
Rasmussen, V. L.....St. Louis, Mo.
Ratcliff, Van W.....Houston, Tex.
Rawlins, Joe C.....Shreveport, La.
Ray, Edward B.....Midland, Tex.
Read, Harold J., State College, Pa.
Reading, Robert E....Dallas, Tex.
Rector, Paul F.....Houston, Tex.
Reeb, Fred C., Corpus Christi, Tex.
Reed, Paul S.....Tulsa, Okla.
Reed, Ramsey M., Birmingham, Ala.
Reese, H. L.....Indianapolis, Ind.
Reese, Max.....Grayville, Ill.
Reeves, B. M.....Marshall, Tex.
Reichard, Edmund C., Barber, N. J.
Reid, J. C.....Dallas, Tex.
Reid, Keith, K.....New Kensington, Pa.
Reinhardt, G. A.....Youngstown, Ohio
Reinhardt, Wm., Los Angeles, Calif.
Reinhart, Fred M.....Washington, D. C.
Renshaw, William G.....Brackenridge, Pa.
Rhodes, E. O.....Pittsburgh, Pa.
Rhodes, George I., New York, N. Y.
Rhodes, H. A.....Houston, Tex.
Riall, Lindsey W....Shreveport, La.
Rice, E. L.....St. Louis, Mo.
Rice, R. J.....Houston, Tex.
Rice, William R.....Houston, Tex.
Rich, Newton D.....Chicago, Ill.
Richard, Charles S.....Holmes, Pa.
Richards, S. L., Jr.....Corpus Christi, Tex.
Richards, Walter C...St. Louis, Mo.
Richardson, John I.....South Gate, Calif.
Ricksecker, Ralph E.....Cleveland, Ohio
Riddick, Thomas M.....New York, N. Y.
Riddle, H. S.....Columbus, Ohio
Ridenour, Charles A.....Beaumont, Tex.
Riegel, G. M.....Massillon, Ohio
Riegelman, Philip B.....Kansas City, Kan.
Rigg, Richard W.....Corning, N. Y.
Riley, W. A.....Memphis, Tenn.
Riling, William W....Houston, Tex.
Rimbach, Richard...Pittsburgh, Pa.
Rimbault, E. L., Jr...Whiting, Ind.
Rinehart, Evan....New York, N. Y.
Ringer, Francis.....Uwchland, Pa.
Rio, Anthony J.....Chicago, Ill.
Riordan, Maurice A...Houston, Tex.
Riordan, M. B., Los Angeles, Calif.
Rios, Juan Rios.....Havana, Cuba
Rippie, Charles W.....New York, N. Y.
Riseling, T. M.....Oklahoma City, Okla.
Robbins, John T., New York, N. Y.
Roberson, Frank.....Gary, Ind.
Roberts, John P.....Houston, Tex.
Roberts, L. J.....Amarillo, Tex.
Roberts, R. G.....Chicago, Ill.
Robertson, James P., Omaha, Neb.
Robeson, Ralph M.....Los Angeles, Calif.
Robinson, Harold A.....Midland, Mich.
Robinson, T. J.....Houston, Tex.
Robson, Arthur D.....Staten Island, N. Y.
Roddey, O. C.....Monroe, La.
Roddy, David F.....Denison, Tex.
Roden, Harry....Port Neches, Tex.
Roesler, Ewald A.....Houston, Tex.
Rogers, John A.....Tulsa, Okla.
Rogers, Oscar F.....Waukegan, Ill.
Rogers, R. R.....Ottawa, Canada
Rogers, Walter F....Houston, Tex.
Rogerson, J. B.....El Dorado, Ark.
Rogness, E. C.....San Diego, Calif.
Rohrman, F. A.....Boulder, Colo.
Rolfs, E. L.....Houston, Tex.
Roll, Kempton H., New York, N. Y.
Romig, O. E.....Pittsburgh, Pa.
Rondeau, H. S.....Chicago, Ill.
Ronningen, H. A., Vicksburg, Mich.
Roosa, Max B.....Detroit, Mich.
Rose, Gordon P., Sr...Detroit, Mich.
Rose, Leonard M.....Houston, Tex.
Rose, W. A.....Franklin, Pa.
Rosenthal, Morris..Fort Bliss, Tex.
Ross, Culbertson W.....Washington, D. C.
Ross, George T.....Houston, Tex.
Ross, Kenneth B.....Abadan, South Iran
Rosselle, Douglass T....Miami, Fla.
Rosson, J. H., Jr.....Corpus Christi, Tex.
Routson, L. B.....Cincinnati, Ohio
Royston, John H.....Blawnox, Pa.
Royston, Thos. T.....Blawnox, Pa.
Rozelle, W. W.....Salt Lake City, Utah
Rudolf, Henry T...Jacksonville, Fla.
Rue, Edward C.....Boston, Mass.
Ruffing, Frank M., Brooklyn, N. Y.
Ruhmann, John P.....Wichita Falls, Tex.
Rupf, J. Albert.....Wichita, Kan.
Rupp, Earl V.....Chicago, Ill.
Rush, E. H.....East Chicago, Ind.
Russell, George F., Jr.....Houston, Tex.
Russell, G. I.....Chatham, Ontario, Canada
Russell, John C.....Albuquerque, N. M.
Rutherford, John J. B.....Beaver Falls, Pa.
Rutter, Charles M., Jr.....Pittsburgh, Pa.
Ryznar, J. W.....Chicago, Ill.

S

Saigh, N. A.....San Antonio, Tex.
St. Clair, John C.....London, Ohio
Salmon, Philip A....Newark, N. J.
Sample, Clarence H.....New York, N. Y.
Sandberg, John H....Houston, Tex.
Sandel, Walter J...Lakewood, Ohio
Sanderson, Wiley D., Detroit, Mich.
Sands, George A...New York, N. Y.
Santschi, William Henry.....Columbus, Ohio
Sargeant, James A.....Fort Belvoir, Va.
Saulson, Saul.....Detroit, Mich.
Saut, Jules F.....Detroit, Mich.
Savage, Robert H.....Los Angeles, Calif.
Sawyer, Mark A.....Los Angeles, Calif.
Scamman, Chas. W...Houston, Tex.
Scanlon, D. A.....Cleveland, Ohio
Scarola, V. J.....New York, N. Y.
Scarpa, Oscar.....Da Vinci 32, Milan, Italy
Schauers, Joseph A.....Philadelphia, Pa.
Scheil, Merrill A...Milwaukee, Wis.
Scherer, Lewis F.....Houston, Tex.
Schiff, Melvin J....Belleville, N. J.
Schilling, W. M.....Bell, Calif.
Schlather, Max F.....San Antonio, Tex.
Schlaudt, Clarence A., Trona, Calif.
Schmidt, Herbert W.....Midland, Mich.
Schmidt, J. M., Los Angeles, Calif.
Schmidt, R. W.....Sierra Madre, Calif.
Schmierer, A. F.....Beatrice, Neb.
Schmitz, Carl Edward, Chicago, Ill.
Schmitz, Fred W.....Terre Haute, Ind.
Schneider, Wm. R.....Emeryville, Calif.
Schnepel, Palmer W., Wichita, Kan.
Schoene, C. E.....St. Louis, Mo.
Schofer, Nathan..New York, N. Y.
Schor, Milton.....Chester, Pa.
Schreihart, Edwin C.....South Gate, Calif
Schreiner, William J.....Cincinnati, Ohio
Schreitz, Wm. Gordon.....Annapolis, Md.
Schroth, Harry A., Glendive, Mont.
Schuh, A. E.....Burlington, N. J.
Schultz, R. F.....Wilmington, Del.
Schupp, Carleton H., Westwego, La.
Schwemlein, William.....Parkersburg, W. Va.
Scott, F. L.....Carteret, N. J.
Scott, Glenn C.....Houston, Tex.
Scott, Gordon N.....Los Angeles, Calif.
Scott, Harold H.....Martinez, Calif.
Scott, T. C.....Kokomo, Ind.
Scott, Thomas W.....Odessa, Tex.
Scribner, Leonard.....North Chicago, Ill.
Seagren, G. W.....Pittsburgh, Pa.
Seal, Reed E.....Cleveland, Ohio
Seal, Wm. D.....Indianapolis, Ind.
Searer, Jay C.....North Tonawanda, N. Y.
Seath, John.....Buckingham, Quebec, Canada
Secrest, Leslie C., Ponca City, Okla.
Seidel, G. E.....Chicago, Ill.
Seidman, Stanley M.....Cleveland, Ohio
Seifried, Dean B.....Spring Valley, N. Y.
Self, M. A.....Chicago, Ill.
Senatoroff, N. K.....Los Angeles, Calif.
Servi, Italo S....Cambridge, Mass.
Severance, Wesley A.....Cleveland, Ohio
Sevin, Lloyd L...New Orleans, La.
Seyl, Robert G.....Evanston, Ill.
Seymour, Raymond B.....Mertztown, Pa.
Shackelford, Robert E., Tulsa, Okla.
Shannon, Thos. H.....McKittrick, Calif.
Sharpe, L. G.....Houston, Tex.
Sharpnack, E. V....Cincinati, Ohio
Shaw, A. G.....New York, N. Y.
Shaw, George E.....Houston, Tex.
Shaw, George S.....Shawinigan Falls, P. Q., Canada
Shaw, William E.....Niagara Falls, N. Y.
Sheley, John D.....Hamilton, Ohio
Shelley, L. H.....Houston, Tex.
Shelton, M. J.....La Mesa, Calif.
Shelves, Arthur R.....Chicago, Ill.

Shenton, Frances G. ..... Paulsboro, N. J.
Shepard, Arthur P. ..... Long Island City, N. Y.
Shepard, E. R. ..... Washington, D. C.
Shepard, Harry L. ..... Houston, Tex.
Shepard, Spencer W. ..... Bound Brook, N. J.
Sheppard, Lyle R. ..... Houston, Tex.
Sherer, Clayton M. ..... Holtwood, Pa.
Sheridan, Richard W. ..... Tulsa, Okla.
Sherwood, William C. ..... South Boston, Mass.
Shideler, Norman T. ..... Allison Park, Pa.
Shields, James E. ..... Niagara Falls, N. Y.
Shigley, C. M. ..... Freeport, Tex.
Shipman, Waldo A. ..... Charleston, W. Va.
Shnidman, Louis ..... Rochester, N. Y.
Shoan, Raymond A. ..... Chicago, Ill.
Shobe, E. H., Corpus Christi, Tex.
Shock, D. A. ..... Ponca City, Okla.
Shoor, A. ..... Haifa, Israel
Short, Howard E. ..... Cincinnati, Ohio
Shuldener, Henry L. ..... New York, N. Y.
Shultz, S. T. ..... Dhahran, Saudi Arabia
Shupp, Carl W. ..... Los Angeles, Calif.
Sibley, Robert S. ..... St. Louis, Mo.
Siddall, D. F. ..... Akron, Ohio
Sidwell, Joseph H. ..... San Antonio, Tex.
Siebert, C. A. ..... Ann Arbor, Mich.
Siekmann, John F. ..... Chicago, Ill.
Sill, George H. ..... Philadelphia, Pa.
Sills, T. O., Sr. ..... Concord, N. C.
Sime, Robert M., Washington, D. C.
Simmons, Edward E., Jr. ..... Pasadena, Calif.
Simmons, Julius M. ..... Fort Wayne, Ind.
Simmons, Raymond S. ..... Peoria, Ill.
Simpson, A. D., Jr. ..... Houston, Tex.
Simpson, John B. ..... Jackson, Mich.
Simpson, N. H. ..... Fort Worth, Tex.
Sims, C. I. ..... Dallas, Tex.
Sims, Chester T. ..... Marble Cliff, Columbus, Ohio
Sittel, V. J. ..... Tulsa, Okla.
Skeie, Kermit ..... Chicago, Ill.
Skinner, Edmond N., Jr. ..... New York, N. Y.
Skog, Ludwig, Jr. ..... Chicago, Ill.
Slavik, Edward W. ..... New Orleans, La.
Sline, Louis L. ..... Houston, Tex.
Slough, Ralph M. ..... Findlay, Ohio
Small, Richard B. ..... El Segundo, Calif.
Smith, A. V. ..... Bala-Cynwyd, Pa.
Smith, Alonzo L. ..... Houston, Tex.
Smith, Arthur, Jr., Midland, Mich.
Smith, Arthur B., Jacksonville, Fla.
Smith, Bartlett J., New York, N. Y.
Smith, Carl B. ..... Chicago, Ill.
Smith, Carl M. ..... Houston, Tex.
Smith, Clair J., Bakersfield, Calif.
Smith, Claude B. ..... San Francisco, Calif.
Smith, H. D., Halifax, N. S. Canada
Smith, Harold L., Kansas City, Mo.
Smith, James M. ..... Shreveport, La.
Smith, Lyle R. ..... Ogallala, Neb.
Smith, Martin B., Alhambra, Calif.
Smith, Nowery J. ..... Houston, Tex.
Smith, O. R. ..... Fort Worth, Tex.
Smith, Philip H. ..... St. Louis, Mo.
Smith, Randal E. ..... Carlsbad, N. M.
Smith, Rex L. ..... Tulsa, Okla.
Smith, Robert M. ..... Houston, Tex.
Smith, Sidney V. ..... Houston, Tex.
Smith, Sydney S. ..... New York, N. Y.
Smith, Tracy E. ..... Odessa, Tex.
Smith, Turner C. ..... Los Angeles, Calif.
Smith, Walter R. ..... Buffalo, N. Y.
Smith, Wm. B., Jr., Shreveport, La.
Smith, William C. ..... Bremen, Ga.
Smith, William E., Jr. ..... Cleveland, Ohio
Smith, William N. ..... Peru, Ill.
Snedaker, Delbert G. ..... Houston, Tex.
Snell, Clark A. ..... New York, N. Y.
Snyder, B. W. ..... Calgary, Alberta, Canada
Snyder, Fred B. ..... Alliance, Ohio
Snyder, Frederick Joseph ..... Venice, Calif.
Snyder, Louis A. ..... Wilmington, Calif.
Sosnin, H. A. ..... Jenkintown, Pa.
Southern, Charles M. ..... Port Arthur, Tex.
Sowards, George ..... Findlay, Ohio
Spafford, Perry Parker ..... Houston, Tex.
Spahr, C. E. ..... Cleveland, Ohio
Spalding, D. A. ..... Midland, Mich.
Spalding, James C., Jr. ..... Dallas, Tex.
Sparks, Robert E. ..... Port Hueneme, Calif.
Spector, Dov. ..... Tel-Aviv, Israel
Speller, Frank N., Pittsburgh, Pa.
Spencer, L. S. ..... Houston, Tex.
Spencer, S. F. ..... Philadelphia, Pa.
Spinks, Lee N. ..... Shreveport, La.
Spoehr, Thomas F. ..... Morton Grove, Ill.
Stafford, Allen D. ..... Houston, Tex.
Staiti, J. J., Long Island City, N. Y.
Standring, J. M. ..... New York, N. Y.
Stanley, Alfred H. ..... Chicago, Ill.
Stanton, W. L. ..... Carthage, Tex.
Staples, William R. ..... San Francisco, Calif.
Starbird, L. C. ..... Dallas, Tex.
Statham, Tom R. ..... Dallas, Tex.
Stauffacher, E. R. ..... Los Angeles, Calif.
Stearns, D. E. ..... Shreveport, La.
Stearns, K. P. ..... Pittsburgh, Pa.
Steel, Edward W. ..... Pittsburgh, Pa.
Stefanides, Victor N. ..... Chicago, Ill.
Stegner, A. L. ..... Houston, Tex.
Stein, Walter F. G. ..... Pampa, Tex.
Steinberger, Chester ..... Houston, Tex.
Stelzer, James G. ..... Jackson, Mich.
Stephan, Dean E. ..... Los Angeles, Calif.
Stephens, E. H. ..... Wichita, Kan.
Stephens, Foster M. ..... Los Angeles, Calif.
Stephens, Robert A. ..... Easton, Pa.
Stephenson, G. W. ..... Corpus Christi, Tex.
Stephenson, James F., Houston, Tex.
Stephenson, R. B. ..... Dayton, Ohio
Stericker, William, Drexel Hill, Pa.
Stern, Milton ..... Cambridge, Mass.
Sterne, Cecil M. ..... Long Island City, N. Y.
Sterrett, Elton ..... Houston, Tex.
Stevens, Robert B. ..... Houston, Tex.
Stevens, Ward W. ..... Monroe, La.
Stevenson, Ralph Austin ..... Los Angeles, Calif.
Stewart, Alex ..... New York, N. Y.
Stewart, C. A. ..... New Orleans, La.
Stewart, Edwin L., New York, N. Y.
Stewart, William Fred, Tulsa, Okla.
Stewart, W. H. ..... Beaumont, Tex.
Stilgenbauer, Ned T. ..... Tulsa, Okla.
Stirling, J. C. ..... Tulsa, Okla.
Stivale, Joseph J., Brooklyn, N. Y.
Stivers, F. A. ..... Tulsa, Okla.
Stobaugh, Robert B., Jr. ..... Baton Rouge, La.
Stobie, John J., Jr. ..... Chicago, Ill.
Stockhausen, Frank H. ..... Milwaukee, Wis.
Stoertz, Howard ..... Philadelphia, Pa.
Stokes, R. A. ..... Mathis, Tex.
Stokes, William S. ..... Huntington Park, Calif.
Storm, Arthur E., Associated, Calif.
Story, E. B. ..... Ambridge, Pa.
Stott, Tom ..... Morton Grove, Ill.
Strachan, John F. ..... London, E. C. 2, England
Strange, Harold T. ..... Mobile, Ala.
Strawn, Lynn Rudolph ..... Port Neches, Tex.
Streever, Otis J. ..... Newport News, Va.
Streicher, Lee ..... Laverne, Calif.
Streit, Frank H. ..... Columbus, Ohio
Strom, C. F. ..... Newark, N. J.
Stromquist, Russell C. ..... Pittsburgh, Pa.
Stromsoe, Douglas A. ..... Azusa, Calif.
Strothman, E. P. ..... Chicago, Ill.
Struben, Frederik J., Jr. ..... Houston, Tex.
Stuart, Linden, Jr. ..... New York, N. Y.
Stull, Fred D. ..... Memphis, Tenn.
Sturrock, Murray G. ..... Pittsburgh, Pa.
Stutzman, Milo J., Kansas City, Mo.
Sudrabin, Leon P. ..... Newark, N. J.
Sullivan, David N. ..... Atlanta, Ga.
Sullivan, E. H. ..... Shreveport, La.
Sullivan, Ray L. ..... Los Angeles, Calif.
Summers, C. H. ..... Miami, Fla.
Supple, George H. ..... Los Angeles, Calif.
Sutter, Carl H. ..... Wichita, Kan.
Suverkrop, E. A. ..... Trenton, N. J.
Svetlik, Joseph ..... Hammond, Ind.
Svrchek, Joseph G. ..... Chicago, Ill.
Swanson, A. R. ..... Atlanta, Ga.
Sward, G. G. ..... Washington, D. C.
Sway, Boris ..... Cincinnati, Ohio
Sweet, F. L. ..... Carrizo Springs, Tex.
Swensson, Stuart J. ..... Pittsburgh, Pa.
Sybert, Jack H. ..... Midland, Tex.

T

Tait, Emmitte P. ..... Atlanta, Ga.
Talmey, Paul ..... Chicago, Ill.
Tandy, Edward H. ..... El Segundo, Calif.
Tator, Kenneth ..... Coraopolis, Pa.
Tatum, Joe F. ..... Hattiesburg, Miss.
Tatum, John M. ..... Hattiesburg, Miss.
Taylor, R. D. ..... Barber, N. J.
Taylor, Thomas A., New York, N. Y.
Teahan, James T. ..... Staten Island, N. Y.
Teale, Edward P. ..... Washington, D. C.
Teeple, H. O. ..... New York, N. Y.
Teh, Chin What ..... Columbus, Ohio
Temmerman, John A. ..... Rochester, N. Y.
Texter, H. G. ..... Tulsa, Okla.
Thalmann, E. H., New York, N. Y.
Thatcher, F. G., Jr. ..... Baton Rouge, La.
Thayer, Starr ..... Houston, Tex.
Thiede, Richard Conrad ..... Grasselli, N. J.
Thomas, Arba H. ..... Middletown, Ohio
Thomas, Beaumont ..... Watertown, N. Y.
Thomas, J. F. J. ..... Ottawa, Ontario, Canada
Thomas, Paul D., New York, N. Y.
Thomas, Ralph W. ..... Waukesha, Wis.
Thompson, Charles H. ..... Brooklyn, N. Y.
Thompson, D. B., New York, N. Y.
Thompson, Harris ..... Chicago, Ill.
Thompson, R. W. ..... Big Spring, Tex.
Thompson, Ralph F. ..... Dallas, Tex.
Thompson, Van ..... Dallas, Tex.
Thomson, J. B. ..... Big Rapids, Mich.
Thornberg, Joseph E. ..... Niagara Falls, N. Y.
Thorney, Charles E., Jr. ..... Houston, Tex.
Thornhill, W. H. T. ..... Westfield, N. J.
Thornton, J. A., Jr. ..... Cleveland, Ohio
Tibbetts, E. F. ..... New York, N. Y.
Tice, E. Allen ..... New York, N. Y.
Tietze, I. B. ..... Bartlesville, Okla.
Timberlake, Philip S. ..... Birmingham, Ala.
Tisdale, O. R. ..... Houston, Tex.
Titsworth, Edwin J., Boston, Mass.
Titterington, Y. W. ..... Tulsa, Okla.
Todhunter, Harold A. ..... Los Angeles, Calif.
Tohline, Max B. ..... Beaumont, Tex.
Tomb, H. H. ..... Lake Charles, La.
Tompkins, Albert H., Jr. ..... Los Angeles, Calif.
Tour, Sam ..... New York, N. Y.
Traber, John P. ..... Atlanta, Ga.
Tracey, Edward J. J., Jr. ..... State College, Pa.
Tracy, Arthur W. ..... Waterbury, Conn.
Treichler, H. E. ..... Newgulf, Tex.
Treseder, Richard S. ..... Emeryville, Calif.
Trilsch, John D. ..... Houston, Tex.
Trishman, L. E. ..... Ambridge, Pa.
Trissal, J. M. ..... Chicago, Ill.
Troseth, Ralph ..... Midland, Tex.
Trouard, Sidney E. ..... New Orleans, La.
Troupe, Ralph A. ..... Louisville, Ky.
Trueblood, Howard M. ..... Dobbs Ferry, N. Y.
Tuggle, Layton C. ..... Houston, Tex.
Turbeville, Louis R. ..... Dallas, Tex.
Turner, C. D. ..... Philadelphia, Pa.
Turner, Delber W. ..... Houston, Tex.
Turner, Elmer A. ..... Malden, Mass.
Tuthill, Arthur H. ..... Baton Rouge, La.

U

Ubben, James E. ..... Dallas, Tex.
Uhlig, H. H. ..... Cambridge, Mass.
Ullrich, A. H. ..... Austin, Tex.
Underwood, C. F. ..... Aliquippa, Pa.
Underwood, O. G. ..... Chicago, Ill.
Unruh, Earl W. ..... Independence, Kan.
Updegraff, Norman C. ..... Louisville, Ky.
Upton, Frederick P. ..... Washington, D. C.
Urian, James H., Marcus Hook, Pa.

V

Van Akin, William J. ..... E. Rutherford, N. J.
Vance, Robert W. ..... Salt Lake City, Utah
Vandaveer, F. E. ..... Cleveland, Ohio
Vande Bogart, L. G. ..... Chicago, Ill.
Van Delinder, L. S. ..... South Charleston, W. Va.
Van Der Baan, S. J. ..... Curacao, D. W. I.
Vander Hoeven, H. ..... The Hague, Holland
Van Der Horst, Hendrik ..... Olean, N. Y.
Van De Water, Donald F. ..... Philadelphia, Pa.
Vangsnes, K. T. ..... Pasadena, Calif.
Van Horne, Roger H. ..... Niagara Falls, N. Y.
Van Houten, Leslie P. ..... New York, N. Y.
Vanick, James S., New York, N. Y.
Van Loo, Maurice ..... Chicago, Ill.
Van Natta, C. A. ..... Chicago, Ill.
Van Petton, Oliver W. ..... Charleston, W. Va.
Van Rysselberghe, Pierre ..... Eugene, Ore.
Van Valkenburg, Jack ..... Oklahoma City, Okla.
Van Vliet, R. ..... Staten Island, New York, N. Y.
Vaughan, Charles E. ..... West Monroe, La.
Vaughan, Wm. H. ..... Houston, Tex.
Vaurio, V. W. ..... Pittsburgh, Pa.
Veech, William A. ..... Caracas, Venezuela, S. A.
Vereeke, Edwin Wm. ..... Cleveland, Ohio
Verink, Ellis D., Jr. ..... New Kensington, Pa.
Vidovic, Paul P. ..... Baton Rouge, La.
Viele, S. M. ..... Swarthmore, Pa.
Vines, E. D. ..... Woodward, Ala.
Vogel, Alfred J. ..... Andrews, Tex.
Volkening, V. B. ..... Freeport, Tex.
Vondrasek, H. W., Brentwood, Mo.

W

Waber, James Thomas ..... Los Alamos, N. M.
Wachter, Aaron ..... Emeryville, Calif.
Wade, O. W. ..... Independence, Kan.
Wade, Paul A. ..... Houston, Tex.
Wafer, George W. ..... Shreveport, La.
Wagner, Carl ..... Fort Bliss, Tex.
Wagner, Ernest F. ..... Burlington, N. J.
Wagner, Frank W. ..... Lorain, Ohio
Wahlquist, Hugo W. ..... New York, N. Y.
Wahlquist, K. D. ..... Dallas, Tex.
Wainman, L. G. ..... El Paso, Tex.
Wainwright, Ray M. ..... Urbana, Ill.
Wait, J. R., Jr. ..... Houston, Tex.
Walczak, M. R. ..... New York, N. Y.
Waldie, Donald J. ..... Los Angeles, Calif.
Waldrip, H. E. ..... Houston, Tex.
Waldron, Leo J. ..... Kensington, Md.
Walker, Basil G. ..... Minneapolis, Minn.
Walker, Henry S. ..... Detroit, Mich.
Walker, Hiram ..... Lockport, N. Y.
Walker, Jack G. ..... Houston, Tex.
Walker, Jack R. ..... Shreveport, La.
Walker, James D. ..... Marion, Ohio
Wallace, Eugene W. ..... Houston, Tex.
Wallace, William P. ..... Oklahoma City, Okla.
Wallnau, Carl N., Jr. ..... New York, N. Y.
Walne, W. R. ..... Houston, Tex.
Ward, Charles F. ..... Corpus Christi, Tex.
Waring, W. H. ..... Houston, Tex.
Warner, Clarence J. ..... Cleveland, Ohio
Warner, Eugene C. ..... Barberton, Ohio
Waterbury, C. L. ..... Chicago, Ill.
Waterman, Howard E. ..... Boise, Idaho
Waters, F. O. ..... Los Angeles, Calif.
Watkins, Franklin M. ..... Harvey, Ill.
Watkins, Jesse L. ..... Iraan, Tex.
Watson, M. P. ..... New Orleans, La.
Watson, T. R. B. ..... Toronto, Ontario, Canada
Watts, Admiral A. ..... Columbus, Ohio
Watts, Bruce B. ..... Lincoln, Neb.
Watts, John C., Jr. ..... Houston, Tex.
Wayman, L. A. ..... Fort Worth, Tex.
Weast, Robert C. ..... Cleveland, Ohio
Weber, Martin K. ..... Emeryville, Calif.
Weede, J. D. ..... Hempstead, N. Y.
Wegner, Harold C. ..... San Francisco, Calif.
Weigele, T. W. ..... Detroit, Mich.
Weidler, W. E., Jr. ..... Houston, Tex.
Weiss, George H., Philadelphia, Pa.
Welker, John W. ..... Philadelphia, Pa.
Wells, C. Kenyon ..... Long Beach, Calif.
Wells, J. Donaven ..... Tulsa, Okla.
Welsh, Myron E. ..... Houston, Tex.
Weppner, Richard A. ..... Philadelphia, Pa.
Werner, Daniel R. ..... Chicago, Ill.
Wertz, Cyril J. ..... Cleveland, Ohio
Wescott, Blaine B., Pittsburgh, Pa.
West, C. H. ..... Elizabeth, N. J.
West, John B. ..... Atlanta, Ga.
West, Lewis H. ..... Norwood, Pa.
Westcott, Ralph M. ..... Pasadena, Calif.
Wheatlake, B. K. ..... Denver, Colo.
Wheeler, A. W. ..... Shreveport, La.
Wheeler, Roger M. ..... Tulsa, Okla.
Whidden, Ira ..... Opa Locka, Fla.
White, Robert L. ..... Degolia, Pa.
White, Robert P. ..... Harvey, La.
White, W. C. ..... Atlanta, Ga.
White, W. J. ..... Kirkwood, Mo.
Whiteneck, L. L. ..... Long Beach, Calif.
Whiting, Drew T. ..... Shreveport, La.
Whiting, L. R. ..... New York, N. Y.
Whitley, Basil J., Jr., Houston, Tex.
Whitney, F. L. ..... St. Louis, Mo.
Whitney, G. W. ..... Los Angeles, Calif.
Wicen, Robert E. ..... Milwaukee, Wis.

Wickens, T. L.....Houston, Tex.
Widmer, Charles Max.....
.....Cedar Rapids, Iowa
Wilbanks, Hugh, Jr.....
.....Corpus Christi, Tex.
Wilde, H. D.....Houston, Tex.
Wilhite, James B....Louisville, Ky.
Wilkes, Frank M....Shreveport, La.
Wilkes, John F.....Chicago, Ill.
Wilkinson, A. C.....
.....Ponca City, Okla.
Wilkinson, Horatio L.....
.....Brooklyn, N. Y.
Williams, Chas. W...Louisville, Ky.
Williams, Geo. T...Davenport, Iowa
Williams, Guy F.....Tulsa, Okla.
Williams, Leonard W.....
.....Coatesville, Pa.
Williamson, Merritt A.....
.....Hammond, Ind.
Williamson, T. D.....Tulsa, Okla.
Williamson, T. D., Jr...Tulsa, Okla.
Williamson, Theodore...Dallas, Tex.
Willson, B. F.....
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Willson, J. P.....Houston, Tex.
Wilmoth, E. G.....Enid, Okla.
Wilson, D. W.....Cleveland, Ohio
Wilson, Fred V.....Beaumont, Tex.
Wilson, J. B.....St. Louis, Mo.
Wilson, John R....McKeesport, Pa.
Wilson, P. S.....Glen Ridge, N. J.
Wilson, Sam.....Tulsa, Okla.
Wilson, T. A....Farmington, N. M.
Wilten, Harry M.....
.....Port Arthur, Tex.
Wimer, C. J.....Dallas, Tex.
Winham, E. S.....Houston, Tex.
Winters, B. W.....Atlanta, Ga.
Wirene, W. A...Schenectady, N. Y.
Wisdom, James A.....Van, Tex.
Wogan, Philip B.....Westwego, La.
Wolf, Edgar F.....Baltimore, Md.
Wolfe, H. E.....Great Bend, Kan.
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Wood, C. Lee.....Houston, Tex.
Wood, Elgean I.....Houston, Tex.
Wood, F. T., Jr.....
.....Santa Monica, Calif.
Wood, Hershel J.....Houston, Tex.
Wood, William A., Jr.....
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.....Pittsburgh, Pa.
Woodman, Frank W.....
.....Lake Charles, La.
Woodruff, Warren E.....
.....Long Beach, Calif.
Woods, Eldro M.....
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Woody, Charles L.....Houston, Tex.
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Wooldridge, Kent E.....
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Wright, Edward C.....
.....Long Beach, Calif.
Wright, Emerson H.....Apollo, Pa.
Wright, Gordon R.....
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Wright, Lewis S.....Ashland, Ky.
Wright, Nathan E., Beaumont, Tex.
Wright, Randolph Earle.....
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Wyche, Ernest H....Coatesville, Pa.

Y

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.....Hicksville, L. I., N. Y.
Yates, Clarence C.....
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Yates, Louie N.....Taft, Tex.
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Young, C. A.....Dallas, Tex.
Young, Frank A., Philadelphia, Pa.
Young, George H., Pittsburgh, Pa.
Young, James W.....
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Young, Louis N.....
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Young, Robert J., Ridgewood, N. J.

Z

Zahm, E. L. E.....Parsons, Kan.
Zajac, Ted S.....Houston, Tex.
Zange, Max.....St. Louis, Mo.
Zapffe, Carl A.....Baltimore, Md.
Zauner, John Hudson.....
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Zedler, Otto F.....Houston, Tex.
Ziebold, H. O.....St. Louis, Mo.
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Zimmerer, Robert I.....
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Zinser, A. L.....Austin, Tex.
Zipper, Donald H.....Chicago, Ill.
Zorko, Frank Anton V.....
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Zuefeldt, Roy H.....Jal, N. M.
Zvarick, Albert J., Norristown, Pa.

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The names followed by an asterisk (*) are those of Junior Members

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HOIBERG, Arnold J., Lion Oil Co.
ROGERSON, J. B., Lion Oil Co.

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MAYWOOD

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ORINDA

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YOUNG, Robert J., Hill Hubbell & Co., Div. of General Paint Corp., 642 Spring Ave.

RIVERSIDE

FREYNIK, Henry S., The Riverside Metal Co.

ROSELLE PARK

NORTHUP, Maynard S., Standard Oil Development Co., Elizabeth, N. J. For mail: 35 W. Roselle Ave.

SOUTH AMBOY

LIESENBEIN, Robert P., National Lead Co., Titanium Div., Box 58.

TRENTON

SUVERKROP, E. A., John A. Roebling's Sons Co., 640 S. Broad St.

UNION

DOUGHTY, S. E., The Carpenter Steel Co., Alloy Tube Div., Springfield Rd.
MORRISON, Barclay, The Carpenter Steel Co., Springfield Rd.

WEEHAWKEN

ALFKE, C. J., Hackensack Water Co., 4100 Park Ave.

W. ENGLEWOOD

MILLER, M. C., Ebasco Services, Inc., New York, N. Y. For mail: 1142 Emerson Ave.

WESTFIELD

PITTMAN, Charles U., Koppers Co.
THORNHILL, W. H. T., Wailes Dove-Hermiston Div., Koppers Co., Box 390.

NEW MEXICO

ALBUQUERQUE

RUSSELL, John C., United Gas Pipe Line Co., Shreveport, La. For mail: 410 S. Princeton.

CARLSBAD

DOUGLASS, E. W., Potash Company of America, Box 31.
HOLT, James B., International Minerals & Chemical Corp.
SMITH, Randal E., Potash Company of America, Box 31.

FARMINGTON

WILSON, T. A., Southern Union Gas Co., Box 337.

JAL

ZUEFELDT, Roy H., The Texas Co., Box 903*

LOS ALAMOS

WABER, James Thomas, Los Alamos Scientific Laboratories, Box 1663.

NEW YORK

BRIARCLIFF MANOR

DEUBER, Carl G., Centro Research Laboratories, Inc., Sleepy Hollow Rd.

BROOKLYN

BERMANN, Morton, Brooklyn Union Gas Co., 197 St. James Place.
CAMERON, William B., Brooklyn Union Gas Co., 176 Remsen St.
CHRIST, George J., New York Telephone Co., 101 Willoughby.
DIEHLMAN, George, Research Laboratories, National Lead Co., 105 York St.
EICKHOFF, Arnold J., National Lead Co., Research Laboratories, 105 York St.
HALE, William L., The Debevoise Co., 968 Grand St.
HAWKE, David L., National Lead Co., Research Labs., 105 York St.
MOORE, Roy W., Socony-Vacuum Oil Company Labs., 412 Greenpoint Ave.
PAIGE, Henry, 576 E. 91st St.*
RUFFING, Frank M., Magnode Products Co., Inc., 139 Banker St.
STIVALE, Joseph J., Brooklyn Varnish Manufacturing Co., Inc., 50 Jay St.
THOMPSON, Charles H., New York Telephone Co., 101 Willoughby St.
WILKINSON, Horatio L., The Debevoise Co., 968 Grand St.

BUFFALO

BIONDOLILLO, Sando, Bell Aircraft Corp., 411 Baynes.
CHANDLER, John W., Nukem Products Corp., 111 Colgate Ave.
DuBOIS, Carlton H., Socony-Vacuum Oil Co., Inc., 503 Elk St.
KAUFMANN, D. W., International Salt Co., Inc., Marine Trust Bldg.
NEUHAUS, Richard, Nukem Products Corp.
NICHOLSON, C. T., Buffalo Niagara Electric Corp., Office Library, Electric Bldg.
SMITH, Walter R., Nukem Products Corp., 111 Colgate Ave.

CORNING

RIGG, Richard W., Corning Glass Works.

DOBBS FERRY

TRUEBLOOD, Howard M., 96 Bellair Drive.

FLUSHING

McCULLOUGH, Harold M., Sylvania Electric Products, 149-49 22nd Ave.*

GARDEN CITY

DAVIDSON, James L., Jr., Long Island Lighting Co., Oxford Bldg.

HEMPSTEAD

WEEDE, J. D., Standard Oil Development Co., New York, N. Y. For mail: 57 Oakland St.

HICKSVILLE

YAHNKER, W. F., The Glasfloss Corp., New South Rd.

LOCKPORT

WALKER, Hiram, Harrison Radiator Div., General Motors Corp.

LONG ISLAND CITY

BARNES, Frank H., The Patterson-Sargent Co., 49-20 Van Dam St.
FRIEDMAN, Charles, Paragon Paint & Varnish Corp., 5-49 46 Ave.
GRAVES, Colburn R., Long Island Lighting Co., Stewart Ave., Garden City.
GRAY, A. E., Pipe Protection Service, Inc., 2616 Skillman Ave.
HALL, Kenneth G., Pipe Protection Service, Inc., 2616 Skillman Ave.
McWATERS, Raymond J., Metallizing Engineering Co., Inc., 38-14 30th St.
SHEPARD, Arthur P., Metallizing Engineering Co., 38-14 30th St.
STAITI, J. J., General Chemical Div., Allied Chemical & Dye Corp., Box 149.
STERNE, Cecil M., Metropolitan Refining Co., Inc., 50-23 Twenty-third St.

MT. VERNON

LATTIN, Benton Calver, Westchester Lighting Co., 9 S. First St.

NEW YORK

ALTENBURG, Charles J., Gibbs & Cox, Inc., 21 West St.
ANDREW, Harold O., Moore-Publishing Co., Inc., 9 E. 38th St.
AYRES, Robert Finley, Oakite Products, Inc., 22 Thames St.
BAGNELL, William E., Ebasco Services, Inc., 2 Rector St.
BAILEY, Clark A., Johns-Manville Sales Corp., 22 E. 40th St.
BAKER, Ralph D., National Lead Co., 111 Broadway.
BALDWIN, L. A., Johns-Manville Sales Corp., 22 E. 40th St.
BARRON, Donald W., Albert F. Ganz, Inc., 511 Fifth Ave.
BATTLE, Thomas J., Koppers Co., Inc., New York, N. Y. For mail: 629 W. 115th St.
BEBBINGTON, Marguerite, International Nickel Co., Inc., 67 Wall St.
BECKER, Wm. D., Burns & Roe, Inc., 233 Broadway.
BENNETT, A. T., Mathieson Chemical Corp., 60 East 42nd St.
BOYD, George E., Koppers Co., Inc., 350 Fifth Ave.
BREMER, Clarence, Oakite Products, Inc., 22 Thames St.
BRITTON, H. B., Middle East Pipe Line Co., 25 W. 45th St.
BUCHANAN, Walter A., Burns & Roe, Inc., 233 Broadway.
CARR, Reid L., Columbian Carbon Co., 41 E. 42nd St.
COLE, Frank H., Walworth Co., 60 East 42nd Street.
COLLINS, Walter F., New York Central Railroad Co., 466 Lexington Ave.
COURT, W. F., Shell Oil Co., Inc., 50 W. 50th St.
COWART, B. C., Barrett Div., Allied Chemical & Dye Corp., 40 Rector St.
COYLE, T. G., United Chromium, Inc., 51 E. 42nd St.
CROSBY, William L., Consolidated Edison Company of New York, Inc., 708 1st Ave.
DANTZ, Thmoas M., The Ruberoid Co., 500 Fifth Ave.
DE MEY, C. F., Columbia Engineering Corp., 120 E. 41st St.
DEVOLUY, Raymond, C. A. Woolsey Paint & Color Co., Inc., 229 E. 42nd St.
DEWEY, Wm. S., New York Telephone Co., 140 West St.
DICKINSON, L. R., Socony-Vacuum Oil Co., Inc., 26 Broadway.
DONOVAN, Lewis B., Consolidated Edison Company of New York, Inc., 4 Irving Place.
EVERETT, Ralph H., M. J. Merkin Paint Co., Inc., 1441 Broadway.
FARKAS, Howard, The U. S. Stoneware Co., 60 E. 42nd St.
FELLER, Eugene W. F., McGraw-Hill Publishing Co., 330 W. 42nd St.
FETTER, Edmond C., Chemical Engineering, 330 W. 42nd St.
FLENTJE, Martin E., American Water Works Co., 50 Broad St.
FOSTER, Albert C., Standard Brands, Inc., 595 Madison Ave.
FRIEND, W. Z., International Nickel Co., Inc., 67 Wall St.
FRIZ, Nelson, Esso Standard Oil Co., 15 W. 51st St.
GEHLEN, Carl, Carlson Painting Co., 50 Church St.
GERMAN, Alfred, Scovill Manufacturing Co., Chrysler Bldg.
GOLDSBY, Fred L., Chicago Bridge & Iron Co., 165 Broadway.
GORMAN, L. J., Consolidated Edison Company of New York, 4 Irving Place.
GOUDIELOCK, William B. O'Brien, Phelps-Dodge Copper Products Corp., 40 Wall St.
GRAHAM, S. B., American Telephone & Telegraph Co., 195 Broadway.
GRUBER, K. A., Chemical Fireproofing Corp. of New York, 508 E. 117 St.
HAMLIN, Arthur W., Ebasco Services, Inc., 2 Rector St.
HEALEY, Edward Lewis, California Texas Oil Co., Ltd., 551 Fifth Ave.
HELMBRECHT, A. J., The Buckeye Pipe Line Co., 30 Broad St.
HENDERSON, Walter A., New York Telephone Co., 140 West St.
HEVERLY, L. F., Ebasco Services, Inc., 2 Rector St.
HUNTLEY, Harold R., American Telephone & Telegraph Co., 195 Broadway.
JACKSON, B. R., Anglo-Iranian Oil Company, Ltd., 610 Fifth Ave.
JOHNSON, Russell K., Darling Valve & Manufacturing Co., 70 Pine St.
JOHNSTON, Howard E., Dearborn Chemical Co., 205 E. 42nd St.
JORDAN, Harry E., American Water Works Association, 500 Fifth Ave.
KLEIN, Fred. M., Maurice A. Knight Co., 55 W. 42nd St.
KNOWLTON, A. E., Electrical World, 330 W. 42nd St.
KOESTER, H. F., Consolidated Edison Company of New York, Inc., 708 First Ave.
KOPITA, Robert, Peabody Engineering Corp., 580 Fifth Ave.
KRUEGER, Forrest J., National Aniline Div., Allied Chemical & Dye Corp., 40 Rector St.
KULMAN, Frank E., Consolidated Edison Company of New York, Inc., 4 Irving Place.
LAIN, George D., American Iron & Steel Institute, 350 Fifth Ave.
LANG, Franklin, Feedwaters, Inc., 140 Cedar St.
LaQUE, F. L., International Nickel Co., Inc., 67 Wall St.
LEHMANN, Joseph A., Ebasco Services Inc., 2 Rector St.
LOPEZ, Eugene R., Barrett Division, Allied Chemical & Dye Corp., 40 Rector St.
MacADAM, Walter K., American Telephone & Telegraph Co., 195 Broadway.
MAITLAND, T. J., American Telephone & Telegraph Co., 32 Sixth Ave.
MARSHALL, Dwight, St. Joseph Lead Co., 250 Park Ave.
MASON, John F., Jr., International Nickel Co., Inc., 67 Wall St.
MASTROBERTE, Joseph, Otis Elevator Co., 260 11th Ave.
MAY, Thomas P., International Nickel Co., Inc., 67 Wall St.
MEIER, A. O., Shell Oil Co., Inc., 50 West 50th St.
MOE, John L., Ebasco Services, Inc., 2 Rector St.
MONTEL, Joseph L., Water Service Laboratories, Inc., 423 W. 126th St.
MORSE, Robert E., American Gas & Electric Service Corp., 30 Church St.
MORTON, Byron B., International Nickel Co., Inc., 67 Wall St.
MULLER, Herman, Jr., New York & Richmond Gas Co., 691 Bay St., Stapleton, S. I. 4.
NEHER, Frank H., The Flintkote Co., 30 Rockefeller Plaza.
NOLAN, Vincent J., National Carbon Co., 30 E. 42nd St.
NOPPEL, E. P., Ebasco Services, Inc., 2 Rector St.
O'KEEFE, John F., Reynolds Metals Co., 19 E. 47th St.
PERKINS, Wendell L., Ebasco Services, Inc., 2 Rector St.
PETERS, Fred P., Reinhold Publishing Corp., 330 W. 42nd St.
PIRSH, Edward A., Babcock & Wilcox Co., 85 Liberty.
PLACE, George W., American Bureau of Shipping, 45 Broad St.
PLOG, Charles B., Standard-Vacuum Oil Co., 42 Broadway.
POPE, Robert, Bell Telephone Laboratories, 463 West St.
PRIESTLEY, Henry L., Electro Metallurgical Co., 30 E. 42nd St.
RHODES, George I., Ford, Bacon & Davis, Inc., 39 Broadway.
RIDDICK, Thomas M., Consulting Engineer & Chemist, 369 E. 149th St.
RINEHART, Evan, Johns-Manville, 22 E. 40th St.
RIPPIE, Charles W., Lukens Steel Co., 50 Church St.
ROBBINS, John T., Peter A. Frasse & Co., Inc., 17 Grand St.
ROLL, Kempton H., Lead Industries Association, 420 Lexington Ave.
SAMPLE, Clarence H., International Nickel Co., Inc., 67 Wall St.
SANDS, George A., Union Carbide & Carbon Corp., 30 E. 42nd St.
SCAROLA, V. J., Tapecoat Co., 489 Fifth Ave.
SCHOFER, Nathan, Ebasco Services, Inc., 2 Rector St.
SHAW, A. G., Ebasco Services, Inc., 2 Recto.r Street.
SHULDENER, Henry L., Water Service Laboratories, 423 W. 126th St.
SKINNER, Edmond N., Jr., International Nickel Co., Inc., 67 Wall St.
SMITH, Bartlett J., The Debevoise Co., 25 Broadway.
SMITH, Sydney S., Shell Oil Company, Inc., 50 W. 50th St.
SNELL, Clark A., Nicholson & Galloway, Inc., 426-28 E. 110th St.
STANDRING, J. M., American Telephone & Telegraph Co., 195 Broadway.
STEWART, Alex, Research Laboratories, National Lead Co., 111 Broadway.
STEWART, Edwin L., Standard Oil Company of New Jersey, 30 Rockefeller Plaza.
STUART, Linden, Jr., The Barrett Div., Allied Chemical & Dye Corp., 40 Rector St.
TAYLOR, Thomas A., American Telephone & Telegraph Co., 195 Broadway.
TEEPLE, H. O., International Nickel Co., Inc., 67 Wall St.
THALMANN, E. H., Ebasco Services, Inc., 2 Rector St.
THOMAS, Paul D., Asiatic Petroleum Co., Materials Dept., 50 W. 50th St.
THOMPSON, D. B., The New York Central Railroad Co., 466 Lexington Ave.
TIBBETTS, E. F., The Lummus Co., 420 Lexington Ave.
TICE, E. Allen, International Nickel Co., 67 Wall St.
TOUR, Sam, Sam Tour & Co., Inc., 44 Trinity Place.
VAN HOUTEN, Leslie P., American Telephone & Telegraph Co., 100 William St.
VANICK, James S., International Nickel Co., 67 Wall St.
VAN VLIET, R., New York & Richmond Gas Co., 691 Bay St.
WAHLQUIST, Hugo W., Ebasco Services, 2 Rector St.
WALCZAK, M. R., Barrett Div., Allied Chemical & Dye Corp., 40 Rector St.
WALLNAU, Carl N., Jr., Standard Oil Company of New Jersey, 30 Rockefeller Plaza.
WHITING, L. R., Bakelite Corp., 30 E. 42nd St.

NIAGARA FALLS

BINDER, William O., Union Carbide & Carbon Research Laboratories, 4625 Royal Ave.
HINCKLEY, Arthur T., Oldbury Electro Chemical Co., 5001 Buffalo Ave.
SHAW, William E., National Lead Co., Titanium Alloy Mfg. Div., Box C, Bridge Station.
SHIELDS, James E., Alox Corp., 3943 Buffalo Ave.
THORNBERG, Joseph E., Hooker Electrochemical Co., 47th St. & Buffalo Ave.
VAN HORNE, Roger H., General Abrasive Co., Bridge Station, Drawer D.

NORTH TONAWANDA

SEARER, Jay. C., Durez Plastics & Chemicals, Inc., Walck Road.

OLEAN

HUTCHCRAFT, D. K., Clark Bros. Co., Inc. Fifth & Lincoln Sts.
PYLES, Russell, Van der Horst Corporation of America, Box 557.
VAN DER HORST, Hendrik, Van der Horst Corporation of America, Box 557.

ROCHESTER

BRANSON, Edward H., General Railway Signal Co., 801 West Ave.
COX, Gilbert L., International Nickel Co., Inc., 45 Exchange St.
CROFTS, E. R., Rochester Gas & Electric Corp., 89 East Ave.
EAST, Leo H., Rochester Gas & Electric Corp., 89 East Ave.
KRUGER, R. E., Rochester Gas & Electric Corp., 89 East Ave.
MacCOLLUM, Donald R., Rochester Gas & Electric Corp., 89 East Ave.
McCANN, Sidney W., The Pfaudler Co., 1000 West Ave.
McCUMBER, Ralph H., Rochester Gas & Electric Corp., 89 East Ave.
SHNIDMAN, Louis, Rochester Gas & Electric Corp., 89 East Ave.
TEMMERMAN, John A., City of Rochester, 34 Court St.

ROME

LYNES, Wilson, Revere Copper & Brass, Inc.

SCHENECTADY

LIEBHAFSKY, Herman A., General Electric Co., Research Laboratory.
MENGEL, Arthur C., American Locomotive Co., N. Jay St.
WIRENE, W. A., General Electric Co., 1 River Road.

SPRING VALLEY

SEIFRIED, Dean B., Rockland Gas Co., Inc., 41 Lawrence St.

STATEN ISLAND

ROBSON, Arthur D., Toch Brothers, Inc., 2600 Richmond Terrace.
TEAHAN, James T., New York & Richmond Gas Co., 2071 Clove Rd. Grasmere.

SYRACUSE

JAMES, Paul W., San-Equip, Inc., E. Brighton & Glen Ave.
JELEN, Frederic C., Allied Chemical & Dye Corp., Solvay Process Div.
KELLOGG, Lucius Andrew, Central New York Power Corp., 300 Erie Blvd E.

WATERTOWN

THOMAS, Beaumont, Stebbins Engineering and Manufacturing Co., Eastern Blvd.

NORTH CAROLINA

ASHEVILLE

COBB, Stephen P., Consulting Gas Engineer, 1 Country Club Rd.

CHARLOTTE

ARNOLD, Wylie H., American Telephone & Telegraph Co., 208 N. Caldwell.
BURNETT, William C., Southern Bell Telephone & Telegraph Co., Box 240.
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CONCORD

SILLS, T. O., Sr., Cannon Mills Co.

TARBORO

LAWRENCE, R. E., Jr., Carolina Telephone & Telegraph Co., 122 E. St. James St.

OHIO

AKRON

FUNK, F. W., Ohio Edison Co., 47 N. Main St.
NERHOOD, H. Elmer, Ohio Edison Co., 325 E. North St.
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ALLIANCE

ENGLE, J. Preston, Babcock and Wilcox Research and Development Dept., Harrisburg and Sawburg Rds.
PHILLIPS, James H., Babcock & Wilcox Co., Harrisburg and Sawburg Rrs.
SNYDER, Fred B., Research & Development Dept., Babcock & Wilcox, Harrisburg & Sawburg.

BARBERTON

BRONSTEIN, Emanuel H., The Ric-Wil Co.
GEGNER, Paul J., Pittsburgh Plate Glass Co.,
WARNER, Eugene C., Akron Sand Blast Co., 50 E. Springfield Rr.

CANTON

CLARK, Claude L., Timken Roller Bearing Co., Steel & Tube Div.

CHILLICOTHE

PRINGLE, George H., The Mead Corp., S. Paint St.

CINCINNATI

FASOLD, G. Arthur, The Philip Carey Mfg. Co., Wayne Ave., Lockland.
FRANEK, John A., 820 Ludlow Ave.*
GOETZ, Alvin C., Eagle-Picher Company, American Bldg.
LEDERER, Lewis M., Inner-Tank Lining Corp., 1097 Wade St.
LINEBACK, George A., Cincinnati Gas & Electric Co., Fourth and Plum Sts.
MALCOM, V. V., The Philip Carey Mfg. Co., Lockland.
McDUFFIE, Roy O., University of Cincinnati.
NUEZEL, E. F., Cincinnati Gas & Electric Co., 323 Plum St.
PAUL, Robert J., Emery Industries, Inc., June and Long Sts.
PFEIFFER, Milton J., The Cincinnati Gas & Electric Co., Box 960.
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SCHREINER, William J., Cincinnati Gas & Electric Co., 323 Plum St.
SHARPNACK, E. V., Reynolds Metals Co., 2535 Gilbert Ave.
SHORT, Howard E., Cincinnati Milling Machine Co., Cimcool Div., Marburg Ave.
SWAY, Boris, The Texo Corp., Dana and Floral Sts.

CLEVELAND

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BIXBY, Willard F., B. F. Goodrich Chemical Co., Rose Bldg.
BOWEN, Milton M., Hill-Hubbell Div., General Paint Corp., 3091 Mayfield Rd.
BROWN, Hugh E., The W. S. Tyler Co., 3615 Superior Ave.
CARSON, John H., The East Ohio Gas Co., 1405 E. Sixth St.
CAYFORD, James M., Glascote Products, Inc., 20900 St. Clair Ave.
CONNELLY, D. J., Williams & Co., Inc., 3700 Perkins Ave.
CRAVER, Albert F., The Cleveland Heater Co., 2310 Superior Ave.
DAVIS, L. W., Aluminum Company of America, 2210 Harvard Ave.
DETRICK, Charles N., Williams & Co., Inc., 3700 Perkins Ave.
DUNASKY, C. F., The Harshaw Chemical Co., 1945 E. 97th St.
DYBLE, Edward, Cleveland Diesel Eng. Div., General Motors Corp., 2160 W. 106th St.
FEBREY, H. H., American Steel & Wire Co., Union Commerce Bldg.
FERGUS, D. J., Cleveland Heater Co., 2310 Superior Ave.
FLOCKE, Frank G., The Thornton Co., 6901 Morgan Ave.
GALLOWAY, Joseph F., Tile-Tite Corp., National City Bank Bldg.
GOSNELL, Everett C., The Colonial Iron Works Co., 17643 St. Clair Ave.
HEATH, John R., The Cleveland Electric Illuminating Co., 75 Public Square.
HEIL, Carl E., Heil Process Equipment Corp., 12901 Elmwood Ave.
HORVATH, Louis, The Ohio Bell Telephone Co., 820 W. Superior Ave.
HOSFORD, Harry W., Harco Corp., 2156 E. Fourth St.
HOXENG, Raymond B., Case Institute of Technology, University Circle.
JENNER, William C., Reliance Electric & Eng. Co., Inc., 1088 Ivanhoe Rd.
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McINTYRE, G. H., Ferro Enamel Corp., 4150 E. 56th St.
MILLS, Lester D., Jr., Standard Oil Company of Ohio, Midland Bldg.
OLIVER, J. Paul, Box 6087.
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POKORNY, Jerome J., The Cleveland Electric Illuminating Co., 75 Public Square.
PRESCOTT, Joseph, Cleveland Electric Illuminating Co., 75 Public Square.
PROCTER, Bryant S., Jr., The H. M. Harper Co., 17600 Detroit Ave.
RICKSECKER, Ralph E., Chase Brass & Copper Co., Inc., 1155 Babbitt Rd.
SCANLON, D. A., American Steel & Wire Co., Union Commerce Bldg.
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SEIDMAN, Stanley M., Ohio Bell Telephone Co., 820 Superior N. W.
SEVERANCE, Wesley A., The Ceilcote Co., Rockefeller Bldg.
SMITH, William E., Jr., The Ceilcote Co., Rockefeller Bldg.
SPAHR, C. E., Sohio Pipe Line Co., Midland Bldg.
THORNTON, J. A., Jr., The Cleveland Tool & Supply Co., 1427 W. Sixth St.
VANDAVEER, F. E., The East Ohio Gas Co., 1405 E. Sixth St.
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WERTZ, Cyril J., The Cleveland Union Terminals Co., 1016 Rushleigh Rd.
WILSON, D. W., Arthur G. McKee & Co., 2300 Chester Ave.
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PRAY, H. A., Battelle Memorial Institute, 505 King Ave.
RIDDLE, H. S., Columbia Engineering Corp., 99 N. Front.
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STREIT, Frank H., Columbus & Southern Ohio Electric Co., 215 N. Front St.
TEH, Chin What, International House, 104 15th Ave.*
WATTS, Admiral A., Engineering Experiment Station, Ohio State University.*

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LUCE, Walter A., The Duriron Co., Inc., Box 1019.
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STEPHENSON, R. B., Dayton Power & Light Co., 25 N. Main St.

ELYRIA

MATTHEWS, Norman A., American Brake Shoe Co., Electro Alloys Div., Taylor St. & Abbe Road.

FINDLAY

SLOUGH, Ralph M., The Ohio Oil Co., 539 S. Main St.
SOWARDS, George, The Ohio Oil Co., 539 S. Main St.

HAMILTON

PLOEDERL, F. J., Cyclic Chemical Co., Permolite Div., North Fifth and Ford Blvd.
SHELEY, John D., The Black-Clawson Co., corner Second & Vine Sts.

HUDSON

FLOOD, Earl F., The Flood Co., Hudson, Ohio. For mail: RD 2.

LAKEWOOD

DAUGHERTY, M. W., Aluminum Company of America, 1239 Overlook Rd.
NEWTON, William E., Cleveland Diesel Engine Div., GMC, Cleveland, Ohio. For mail: 2174 Chesterland Ave.
SANDEL, Waiter J., Coatings for Industry, Inc., 1242 Hall Ave.

LIMA

MOFFETT, J. L., Pipe Line Dept., Ohio Oil Co., Box 719.

LONDON

ST. CLAIR, John C., Route 2.

LORAIN

WAGNER, Frank W., National Tube Co., Lorain Wks., Pearl Ave. & 28th St.

MANSFIELD

KAUFMAN, L. W., Westinghouse Electric Corp., 200 E. Fourth St.

MARION

FELDMAN, Karl T., Sinclair Refining Co., Prod. Pipe Line, 139 N. State St.
WALKER, James D., Sinclair Refining Co., Products Pipe Line, 139 N. State St.

MASSILLON

RIEGEL, G. M., Republic Steel Corp., Metallurgical Laboratory.

MIDDLETOWN

BEAM, Russell C., Armco Drainage & Metal Products, Inc.
BEDFORD, Gordon T., Armco Steel Corp., Market Development Div.
ELLIS, O. B., Armco Steel Corp., Research Laboratories.
HALBIG, John J., Armco Steel Corp., Research Laboratory.
THOMAS, Arba H., Armco Steel Corp., 703 Curtis.

NEWARK

HARRISON, James R., The Pure Oil Co., Box 951.
HUNTER, Wesley L., Pure Oil Co., Heath Refinery*

PAINESVILLE

CAMPBELL, C. Langdon, Diamond Alkali Co.
GREENE, U. T., Diamond Alkali Co., Box 699.
McILRATH, Samuel W., Diamond Alkali Co., Fairport, Ohio. For mail: 715 Lucille Ave.

SHAKER HEIGHTS

RASK, Morris L., Aluminum Co. of America, Cleveland, Ohio. For mail: 2895 Weymouth Rd.

TOLEDO

DALE, Dudley R., The S. M. Jones Co., 624 Segur Ave.
HOWARD, Owen G., Sun Oil Co., Laboratory, Woodville St.
JENSEN, M. G., Owens-Corning Fiberglas Corp., Corrosion Products Sales.

WATERVILLE

CAPAUL, R. W., Glass Fibers, Inc.

WORTHINGTON

GARD, Charles M., Alden E. Stilson & Associates, Columbus, Ohio. For mail: 391 Park Blvd.

YOUNGSTOWN

FETTERS, Karl L., The Youngstown Sheet & Tube Co., Stambaugh Bldg.
FLICKINGER, L. C., The Youngstown Sheet & Tube Co., Campbell Works.
REINHARDT, G. A., Youngstown Sheet & Tube Co.

OKLAHOMA

BARTLESVILLE

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BRYAN, Lloyd, H. C. Price Co., Box 1111.
DEWAR, J. S., H. C. Price Co., Box 1111.
EILERTS, C. Kenneth, Bureau of Mines.
FLEMING, M. C., Phillips Petroleum Co.
HART, James L., National Zinc Co., Inc.
HOLMBERG, M. E., Phillips Petroleum Co.
HUDDLESTON, Wm. E., Huddleston Engineering Co., Box 998.
HUGO, L. A., Phillips Petroleum Company.
PRANGE, Frederick A., Phillips Petroleum Co.
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(With Corporate Representatives)

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VOLUME VI

JANUARY THROUGH DECEMBER

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EDITORIAL AND BUSINESS OFFICES

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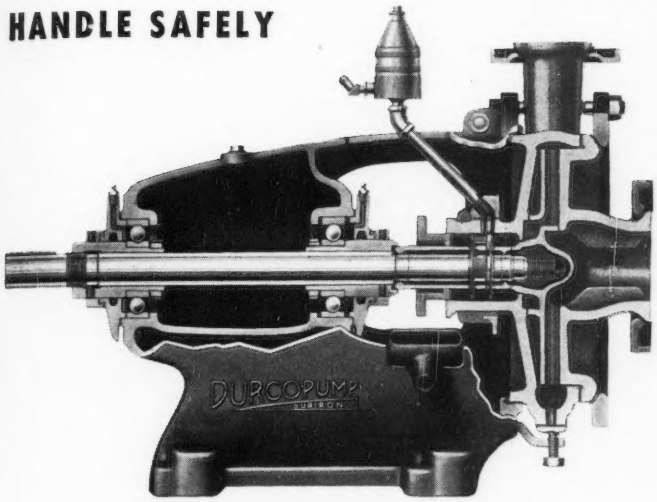

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Malic acid
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